LAKE ROOSEVELT FISHERIES AND LIMNOLOGICAL RESEARCH

1996 ANNUAL REPORT

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This report contains preliminary data and conclusions that may be subject to change. This report may be cited in publications but the manuscript status must be noted.

EXECUTIVE SUMMARY

The Lake Roosevelt Monitoring / Data Collection Program is the result of a merger between two projects, the Lake Roosevelt Monitoring Program (BPA No. 8806300) and the Lake Roosevelt Data Collection Project (BPA No. 9404300). These projects were merged in 1996 to continue work historically completed under the separate projects. This newly merged project will develop a model to predict biological responses to reservoir operations and evaluate the effects of releasing hatchery origin kokanee salmon and rainbow trout on the fishery. The program also evaluates success of various stocking strategies to increase fish harvest while maximizing the return of spawning kokanee salmon to egg collection facilities. Objectives of the Monitoring Program in 1996, included:

1. Collect data on zooplankton biomass and density and limnological characteristics (pH, temperature, dissolved oxygen, conductivity, oxidative reductive potential and secchi disk) at ten locations throughout Lake Roosevelt;
2. Assess entrainment and of tagged rainbow trout;
3. Determine angler pressure and harvest, average size of fish harvested and economic value of the fishery;
4. Estimate the relative abundance of fishes in Lake Roosevelt;
5. Conduct dietary analysis on kokanee salmon, rainbow trout and walleye to assess relative importance of prey items and dietary overlap;
6. Back calculate length at age using scales from kokanee salmon, rainbow trout and walleye;
7. Continue investigations to determine the critical period(s) for olfactory imprinting of kokanee salmon;
8. Assess the best times and locations to release kokanee in order to prevent entrainment, and improve returns to creel and egg collection sites;
9. Compare and contrast data collected during 1996 with previous years to identify changes in lake conditions or the fishery;
10. Participate in operational decisions on lake Roosevelt.

As in previous years, limnological, reservoir operation, zooplankton, net-pen rainbow trout and kokanee salmon tagging data were collected at eleven index stations in Lake Roosevelt. Lake Roosevelt reached a yearly low of 1,227 feet above mean sea level in April and a yearly high of 1,289 feet in July, with a mean yearly reservoir elevation of 1,27 1.4 feet

during 1996. Mean monthly water retention times in Lake Roosevelt during 1996 ranged from 15.7 days in May to 49.2 days in October.

Daphnia spp. densities peaked during the summer months at all sites, and ranged from 100 organisms/ m^3 to 7,2 15 organisms/ m^3. Minimum *Daphnia* spp. densities occurred during the spring, ranging from 0 to 5 organisms/ m^3. Total zooplankton densities also peaked during the summer, ranging from 216 organisms/ m^3 to 16,040 organisms/ m^3. The lower reaches of the lake had the highest *Daphnia* spp. and total zooplankton densities during 1996.

In 1996, a total of 14,948 net-pen rainbow trout were tagged at Kettle Falls and Seven Bays. We had 228 tags returned from Lake Roosevelt or below, yielding a 1.5% return rate. Tag return data suggested high entrainment rates in 1996. Twenty five percent of returned tags were from fish harvested below Grand Coulee Dam, including 89% of those released prior to maximal drawdown. Data collected in 1996 and past years suggests that the highest entrainment rates from Lake Roosevelt coincide with declining water levels, low water retention times, and early (March / April) fish releases.

Mean reservoir elevation, storage volume, and water retention time were reduced in 1996 relative to the last five years. Mean reservoir elevation in 1996 was 6 feet less than in 1995, and was the lowest average elevation since 1991. Mean water retention time was 14.8 days less than in 1995 due in part to a ten foot August drawdown implemented to benefit ESA listed stocks in the Snake River. Average zooplankton densities were lower in 1996 than 1995, as was average zooplankton biomass. A positive correlation between water temperature and *Daphnia* spp. densities was again observed in 1996.

Stocking of rainbow trout and kokanee salmon into Lake Roosevelt began from the Spokane Tribal Hatchery in 1991 and the Sherman Creek Hatchery in 1992. Approximately 2.5 million kokanee salmon and 400,000 rainbow trout were released annually from 1991 through 1993. Numbers of kokanee salmon released during 1995 (approximately 1 million) and 1996 (300,000) were reduced as the hatcheries shifted towards production of yearlings rather than fry, however numbers of rainbow trout released remained consistent with previous years. We estimated that anglers made 195,628 trips to Lake Roosevelt during 1996 with an economic value of $7,629,492. Harvest of kokanee salmon (1,265 fish) and rainbow trout declined dramatically in 1996 relative to 1995 (32,353 kokanee salmon and 76,782 rainbow trout). In contrast, our estimated 1996 harvest of walleye (105,242) increased relative to 1995 (40,185 walleye harvested).

Relative abundance of kokanee salmon in our surveys was also reduced in 1996 (4%) relative to 1995 (20%), whereas relative abundance of walleye and rainbow trout was higher in 1996 (19 and 7%, respectively) than in 1995 (12 and 5%, respectively). Walleye diet has been changing since 1989 with the relative importance of yellow perch declining, and that of other fishes increasing. Yellow perch, a preferred food of walleye, have been declining in relative abundance since 1990, and their reduced abundance may partly account for declining walleye growth since 1992. Feeding habits of kokanee salmon and rainbow trout have not changed appreciably since 1989 in Lake Roosevelt.

From 1992 to 1996, coded wire tagged (CWT) fish were released as residualized smolts into Lake Roosevelt. These fish were imprinted at different life stages and were given an adipose clip and a distinctive coded wire tag. Returning adults would enable us to determine (1) the number entrained from Lake Roosevelt (2) the number harvested by anglers; (2) the number homing to egg collection sites, and (4) the number straying to other locations. Results continued to show that kokanee can be successfully imprinted to artificial odors - morpholine and phenethyl alcohol - as juveniles from hatch through swimup and again as smolts. Fish double exposed to synthetic chemicals at alevin/swimup and smolt stages had the highest rate of homing to egg collection sites (74% of the morpholine exposed fish recovered were captured at morpholine scented streams and 67% of the phenethyl alcohol exposed fish recovered were captured at phenethyl alcohol scented streams). Additionally, fish exposed to synthetic chemicals were recovered in greater numbers and displayed higher homing ability to egg collection sites than fish that were not exposed to synthetic chemicals. Fish exposed to synthetic chemicals and released at Sherman Creek had the most precise homing, with 74% of the total recovered fish captured at Sherman Creek.

Based on the results of this investigation, we recommend the following measures for the investigation and management of the Lake Roosevelt fishery and related biota:

1) Examine changes in available littoral habitat under various drawdown scenarios.

2) Collect information on primary production to examine habitat availability, nutrient assimilation rates, and the relationship with water quality.

3) Increase sampling intensity to better define the effects of reservoir operations on secondary production and estimate. the potential and realized zooplankton production in Lake Roosevelt.

4) Continue investigations into annual growth variations of kokanee salmon and walleye.

5) Assess impacts of walleye predation on kokanee salmon.

6) Begin floy tagging 10,000 kokanee salmon smolts in an attempt to increase angler returns of tagged kokanee salmon, assess the success of various release strategies, and monitor entrainment.

7) Conduct boat based hydroacoustic surveys to examine variations in die1 and spatial distribution of kokanee salmon and rainbow trout.

8) Continue to hold net pen rainbow trout until after maximal drawdown is reached and release more yearling kokanee salmon into the reservoir annually.

9) Study feasibility of collecting additional spawning kokanee at Sherman Creek and continue the egg collection site at Hawk Creek

10) Determine if chemically imprinted and non-imprinted kokanee salmon reared and released at Sherman Creek home back in equal numbers (percentages).

11) Locate alternative stocks of kokanee salmon with better genetic adaptations than those from Lake Whatcom for the Lake Roosevelt Program.

12) Index white sturgeon to establish basic population parameters (condition, age composition, etc.) in Lake Roosevelt.

13) Explore the viability of shifting towards a boat based creel survey to contact more anglers and improve accuracy of creel estimates.

14) Operate Lake Roosevelt as indicated in the Northwest Power Planning Council Fish and Wildlife Program (amended in September, 1995). This program recommends maintenance of water levels above 1,250 feet above mean sea level and water retention times above 30 days.

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SECTION 1

LAKE ROOSEVELT MONITORING / DATA COLLECTION PROGRAM

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ABSTRACT

The Lake Roosevelt Monitoring / Data Collection Program resulted from a merger between the Lake Roosevelt Monitoring Program and the Lake Roosevelt Data Collection Project. This project will model biological responses to reservoir operations, evaluate the effects of releasing hatchery origin kokanee salmon and rainbow trout on the fishery, and evaluate the success of various stocking strategies. In 1996, limnological, reservoir operation, zooplankton, and tagging data were collected. Mean reservoir elevation, storage volume and water retention time were reduced in 1996 relative to the last five years. In 1996, Lake Roosevelt reached a yearly low of 1,227 feet above mean sea level in April, a yearly high of 1,289 feet in July, and a mean yearly reservoir elevation of 1,27 1.4 feet. Mean monthly water retention times in Lake Roosevelt during 1996 ranged from 15.7 days in May to 49.2 days in October. Average zooplankton densities and biomass were lower in 1996 than 1995. Daphnia spp. and total zooplankton densities peaked during the summer, whereas minimum densities occurred during the spring. Approximately 300,000 kokanee salmon and 400,000 rainbow trout were released into Lake Roosevelt in 1996. We estimated 195,628 angler trips to Lake Roosevelt during 1996 with an economic value of \$7,629,492. In 1996, 14,948 rainbow trout were tagged, of which 1.5% (228) were returned by anglers. We estimated 25% entrainment of rainbow trout released in 1996, including 89% of those released prior to peak drawdown. Estimated harvest of kokanee salmon and rainbow trout declined in 1996 relative to 1995, whereas that of walleyes increased. Relative abundance of walleye and rainbow trout increased in 1996 relative to 1995 however, the relative abundance of kokanee salmon declined. Walleye diet has changed appreciably since 1989, whereas that of kokanee salmon and rainbow trout have not. Declining abundance of yellow perch since 1990 may partly account for declining walleye growth since 1992.

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1.0 INTRODUCTION

The Lake Roosevelt Monitoring / Data Collection Program is the result of a merger between two projects, the Lake Roosevelt Monitoring Program (BPA No. 8806300) and the Lake Roosevelt Data Collection Project (BPA No. 9404300). These projects were merged in 1996 due to overlapping support staff and data requirements. The Lake Roosevelt Monitoring / Data Collection Program will continue work historically completed under the separate projects and develop a biological rule curve for Lake Roosevelt.

1.1 Project History

The Lake Roosevelt Monitoring Program began in July, 1988. The primary objective was to determine stocking strategies of hatchery origin kokanee salmon (*Oncorhynchus nerka*) and rainbow trout (*Oncorhynchus mykiss)* that maximized angler harvest and return of kokanee salmon to egg collection facilities. In addition, the project collected baseline data to evaluate the effects of stocking kokanee salmon and rainbow trout on the ecosystem. Tasks of the Monitoring Program were to conduct a year round reservoir wide creel survey, sample the fishery by electroshocking boat during spring, summer and fall, and collect information on fish diet, length, weight and age. Data was analyzed to determine food availability and utilization, growth rates of resident fishes, and angler use information (e.g. harvest).

The Lake Roosevelt Data Collection Project began in July, 1991 as part of the Bonneville Power Administration (BPA), Bureau of Reclamation (BOR), and U.S. Army Corps of Engineer's (USACE) System Operation Review process. This process sought to develop an operational scenario for the Federal Columbia River Hydropower System which minimized impacts to all stakeholders of the Columbia River. The objective of the Data Collection Project was to develop a biological model for Lake Roosevelt that will predict biological responses to different reservoir operation strategies. The model will allow identification of lake operations that minimize impacts on lake biota while addressing the needs of other interests (e.g. flood control, downstream and anadromous fisheries). Major components of the Lake Roosevelt model will be: 1) quantification of entrainment and other impacts to phytoplankton, zooplankton and fish caused by reservoir drawdowns and low water retention times; 2) quantification of the number, distribution, and use of fish prey in the reservoir by season; and 3) determination of seasonal growth of fish species as related to reservoir operations, prey abundance, and utilization.

Previous annual reports for the Lake Roosevelt Data Collection Project include Griffith et al. (1995), Griffith and McDowell (1996), Voeller (1996), Shields and Underwood (1996) and Shields and Underwood (1997). Previous reports for the Lake Roosevelt Monitoring Program include Peone et al. (1990), Griffith and Scholz (1991), Thatcher et al. (1993), Thatcher et al. (1994), Underwood and Shields (1996), Underwood et al. (1996) and Underwood et al. (1997)

1.2 History of Kokanee Salmon and Rainbow Trout Stocking

From 1988 to 1990, kokanee salmon reared at the Ford Hatchery by the Washington Department of Fish and Wildlife (WDFW) were stocked into Lake Roosevelt. Approximately 750,000 kokanee salmon fry were stocked into Sherman Creek and 100,000 kokanee salmon fry were stocked into the Spokane River at Little Falls Dam each year during May or July. Rainbow trout fry were provided to the Lake Roosevelt Net Pen Program by the Spokane Hatchery (WDFW operated) from 1986 to 1990. The number of rainbow trout provided by the Spokane Hatchery began at 50,000 and increased to 276,500 by 1990. Rainbow trout were stocked in net pens during October and held until May or June when they were released as yearlings. The Net Pen Program was operated by the Lake Roosevelt Development Association, a nonprofit volunteer group.

The Spokane Tribal Hatchery went on line in 1990 and began stocking kokanee salmon and rainbow trout into Lake Roosevelt in 199 1. The Sherman Creek Hatchery began rearing and releasing kokanee salmon in 1992. The Spokane Tribal Hatchery is .a full production facility operated by the Spokane Tribe and located on the Spokane Indian Reservation. The Sherman Creek Hatchery is a part time (spring to fall) rearing facility operated by the WDFW and located near Kettle Falls, Washington. Construction and operation of these hatcheries were funded by BPA as partial mitigation for the loss of anadromous salmon and steelhead following the construction of Grand Coulee Dam in 1939. The dam was not equipped with a fish ladder and permanently blocked the migration of anadromous salmon and steelhead to areas above the darn.

The Sherman Creek Hatchery is the primary egg collection facility for kokanee salmon stocked into Lake Roosevelt, and collected eggs are transferred to the Spokane Tribal Hatchery for incubation and rearing. Initial egg stocks were obtained from the Lake Whatcom Hatchery near Bellingham, WA (operated by WDFW), and due to limited adult returns in Lake Roosevelt, kokanee salmon eggs continue to be supplemented by the Lake Whatcom Hatchery. A portion of the kokanee salmon reared in the Spokane Tribal

Hatchery are transferred to the Sherman Creek Hatchery in early spring for imprinting and later release. The hatcheries original production goals were 8 million kokanee salmon fry for release into Lake Roosevelt and 500,000 rainbow trout fry for the Lake Roosevelt Net Pen Program. Approximately 2.5 million kokanee salmon and 400,000 rainbow trout were released annually from 1991 through 1994. Numbers of kokanee salmon released during 1995 (approximately 1 million) and 1996 (300,000) were reduced as the hatcheries shifted towards production of yearlings rather than fry, however numbers of rainbow trout released remained consistent with previous years in 1995, and increased to over 570,000 in 1996.

1.3 Description of Study Area

Lake Roosevelt is a mainstem Columbia River impoundment formed by the construction of Grand Coulee Dam in 1939 (Figure 1.1). Filled in 1941, the reservoir inundates 33,490 hectares at a full pool elevation of 393 m (1290 ft) above mean sea level. It has a maximum width of 3.4 km and a maximum depth of 122 m (370 ft; Stober et al. 198 1). Grand Coulee Dam is a Bureau of Reclamation project operated primarily for power production, flood control, navigation, and irrigation with secondary operations for recreation, fish, and wildlife.

1.4 1996 Study Objectives

Objectives of the Lake Roosevelt Monitoring / Data Collection Project for 1996 were to:

1. Collect data on zooplankton biomass and density and limnological characteristics (pH, temperature, dissolved oxygen, conductivity, oxidative reductive potential and secchi disk) at nine locations throughout Lake Roosevelt and one location in Rufus Woods Reservoir;

2. Assess entrainment of tagged rainbow trout;

3. Determine angler pressure and harvest, average size of fish harvested and economic value of the fishery;

4. Estimate the relative abundance of fish in Lake Roosevelt;

5. Conduct dietary analysis on kokanee salmon, rainbow trout and walleye (*Stizostedion vitreum*) to assess relative importance of prey items and dietary overlap;

6. Back calculate length at age using scales from kokanee salmon, rainbow trout and walleye;

7. Compare and contrast data collected during 1996 with previous years to identify changes in lake conditions or the fishery; and

8. Participate in operational decisions on Lake Roosevelt.

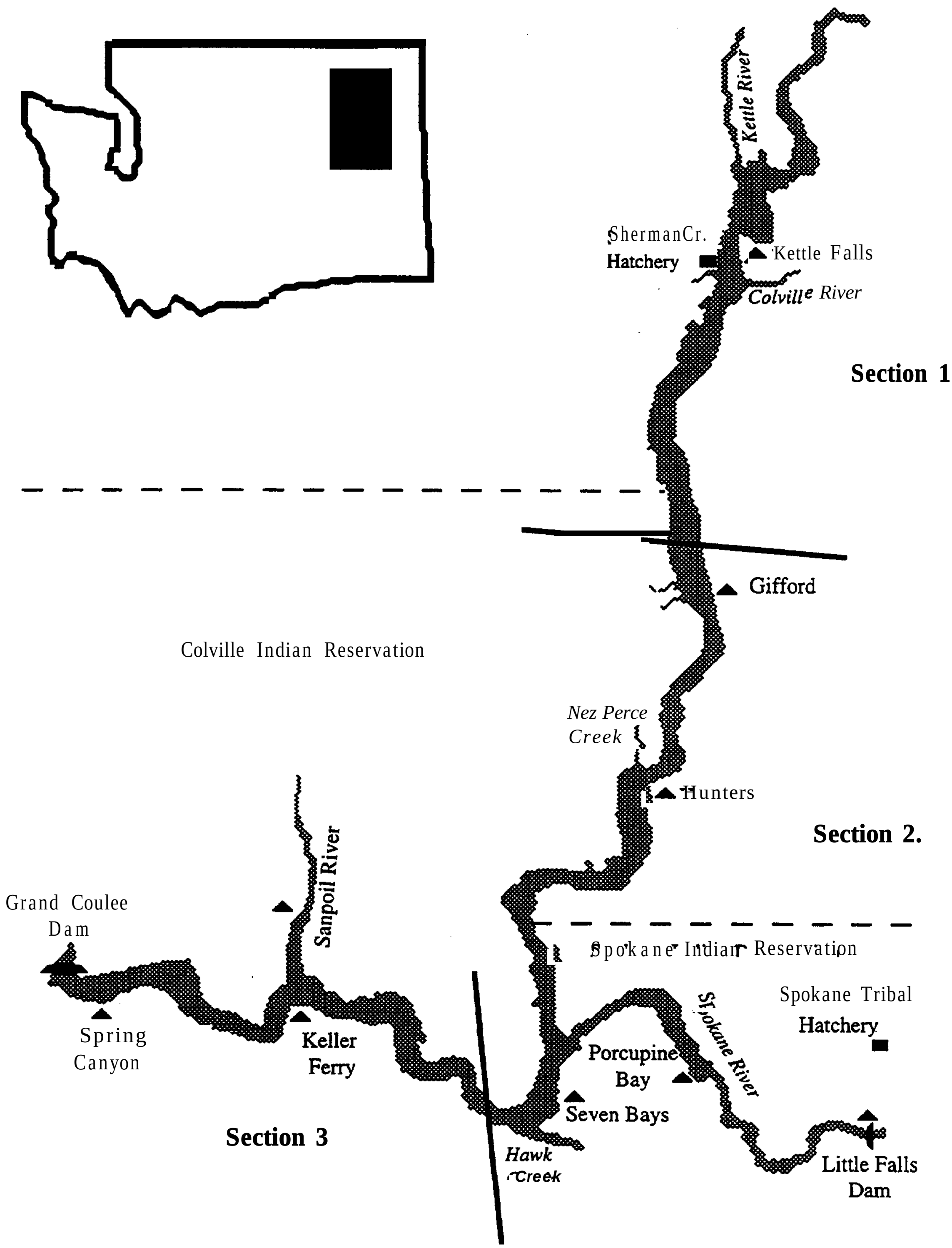


Figure 1.1. Map of Lake Roosevelt, Washington showing standard sampling locations (▲) and sections used for creel surveys and data analysis.

2.0 MATERIALS AND METHODS

2.1 Reservoir Hydrology

Water temperature, pH, dissolved oxygen, conductivity, and oxygen reduction potential were recorded at nine sites in the reservoir using a Hydrolab Surveyor II. Water quality data was collected mid-channel at 3 m intervals to a depth of 33 m at Kettle Falls (Location l), Gifford (Location 2), Hunters (Location 3), Porcupine Bay (Location 4), the Confluence of the Spokane River with the mainstem Columbia (Location confluence), Seven Bays (Location 6), Keller Ferry (Location 7), San Poil River (Location 8) and Spring Canyon (Location 9; Figure 1.1). Secchi disk readings were. taken in conjunction with Hydrolab measurements at each of the above sites. Water quality measurements were collected monthly from March through October at Locations 2,4,6,7, and 9. Measurements at locations 1,3, and 8 were taken in May, July, and October, whereas water quality at the confluence location was recorded in March, April, June, August, and September in 1996. Collection of water quality data continues investigations which began in 1991 (Appendix C).

Water retention times were calculated from daily midnight reservoir elevations (ft) and total outflows in thousand cubic feet per second per day (kcfs). Reservoir elevation and total outflow values were obtained from summary reports for Grand Coulee Dam prepared by the USACE Reservoir Control Center in Portland. Reservoir elevation was converted to volume of water stored (kcfsd) using a reservoir water storage table (USACE 1981). Water retention time was calculated using the formula:

$$\text{Water retention time (days)} = \frac{\text{Reservoir volume (kcfsd)}}{\text{outflow (kcfs)}}$$

Mean monthly reservoir elevations and water retention times were estimated by dividing the sum of daily values for each category by the number of days in each month (Appendix A).

2.2 Zooplankton

Zooplankton samples were collected twice per month (March through December, 1996) from Gifford, Porcupine Bay, Confluence, Seven Bays, Keller Ferry, Spring Canyon, and Rufus Woods. In continuing protocols established in the Lake Roosevelt Monitoring Project, zooplankton were collected from Kettle Falls, Hunters, and the San Poil River three times per year in March, August and October. Samples were taken using a Wisconsin vertical tow plankton net with153 um silk mesh and a radius of 14.5 cm. Triplicate tows were made from a depth of 33 m to the surface at each sampling location within Lake Roosevelt. At Rufus Woods, where main channel river depths average 20 m, three 15 m subsample tows were taken and combined into each of two samples. Time and depth of each tow was recorded on a separate data sheet. Organisms collected were washed into individual 253 ml bottles that contained 10 ml of 37% formaldehyde and 0.5 g of sugar (Rigler 1978). Bottles were labeled with the date, location, and tow number. Organisms were then stained with 1.0 ml of five percent Lugol's solution and 1.0 ml of saturated eosin-y ethanol stain and brought to a volume of 200 mls.

In the laboratory, zooplankton were identified to species using taxonomic keys by Brandlova et al. (1972), Brooks (1957), Edmondson (1959), Pennak (1989), Ruttner-Kolisko (1974), and Stemberger (1979). A Nikon SMZ-10 dissecting microscope with a ring illuminator system and a Nikon Optiphot phase contrast microscope were used for identification. In cases where sample densities were high, three sub-samples were counted using a modified counting chamber (Ward 1955), until 60 organisms or 25 ml of sample was counted (Edmondson and Winberg 1971, Downing and Rigler 1984). Sub-sample volumes depended on the density of organisms in the samples.

Zooplankton densities were calculated for each individual tow and the results of the three tows were averaged to arrive at a single location density. Zooplankton density (# organisms/m3) was calculated using a series of equations. First, the volume (L) of samples collected with the Wisconsin plankton sampler was calculated by the formula:

$$v = \prod r^2 h$$

where:

v	=	volume of the sample (liters);
	=	pi (3.14);
r	=	radius of sampler (cm); and
h	=	depth of sample (m).

Next, microcrustacean zooplankton density (# organisms/ m3) was calculated by the equation:

$$D = \frac{\left(\frac{T_c}{S_n} * \frac{SV}{SSV}\right)}{V} DF*lOOO$$

where:

D	=	density (# organisms/ m3);
Sn	=	number of sub-samples;

SV	=	volume of preserved sample;
SSV	=	sub-sample volume;
v	=	volume sampled with plankton net;
DF	=	dilution factor; and
Tc	=	total number counted of each species of organisms.

Biomass of predominant Cladocera groups (*Daphnia* spp. and *Leptodora kindtii*) *was* determined using the length-weight regressions summarized by Downing and Rigler (1984; Table 2.1). Mean cladoceran length was determined by measuring randomly chosen groups of up to twenty individual Cladocera per group. *Leptodora kindtii* lengths were taken by direct measurement, while all other measurements were made by first calibrating a Nikon Optiphot scope so that 10 micrometer units equaled 1 mm. Individual Cladocera were measured from the top of the head to the base of the carapace, excluding the spine. Observed lengths (micrometer units) were converted to actual lengths (mm) through the use of a conversion factor of 0.1. Actual length data was averaged by species and recorded.

Dry weight of zooplankton was estimated using the equation:

$$\ln w = \ln a + (b)(\ln L)$$

Where:

lnw	=	the natural log of the dry weight estimate (ug) for the Cladocera species;
$\ln a$	=	the natural log of the intercept for the Cladocera species;
b	=	the slope value for the Cladocera species; and
ln L	=	the natural log of the mean length value for the Cladocera species.

Average Cladocera biomass was calculated using the formula:

$$B = (\ln w)(D)$$

Where:

B	=	biomass (mg/m^3);
lnw	=	log of the dry weight estimate for the Cladocera species (μg); and
D	=	density (# organisms/m^3).

Zooplankton entrainment rates were also estimated in 1996. We estimated entrainment rates of zooplankton as the percentage of Spring Canyon total densities observed at the Rufus Woods sampling location.

Table 2.1 Slope (b) and intercept' (In a) values used for the dry weight estimate calculations *.

Cladocera Species	In *a*	*b*
Daphnia galeata mendotae	1.51	2.56
Daphnia retrocurva	1.4322	3.129
Daphnia pulex	2.30	3.10
Daphnia thorata	2.64	2.54
Leptodora kindtii	-0.822	2.67

* Taken from Downing and Rigler, 1984.

2.3 Rainbow Trout Tagging

Tagging studies were conducted on Lake Roosevelt using age one net-pen reared rainbow trout. Fish chosen for this study were randomly netted out of holding pens, measured to the nearest millimeter and tagged with individually numbered floy tags. Orange tags were used in 1996. Prior to tagging and length measurement, groups of up to 200 fish were anesthetized with carbon dioxide. This process involved placing 50 galIons of lake water into a large plastic holding tank and bubbling CO2 into it from a 750 psi main tank through two 12 inch oxygen stones at a rate of 30 psi for three minutes. pH levels in the holding tank were monitored with a Hydrolab II surveyor and buffered to a level of 6.5 to 7.0 with calcium bicarbonate (Post 1979). When acceptable pH ranges were attained, fish were netted from holding pens and placed in the CO_2 water where they were rendered unconscious within one minute allowing for easy handling. Once measured and tagged, all fish were allowed to recuperate for up to 30 minutes in 20 gallon containers prior to being returned to the net pens. Tagged fish were then held in net pens for three weeks at which time mortality rates were calculated and fish released. Overall mortality rates for this process were less than 0.5%. In 1996, 4,998 fish were tagged at Kettle Falls and 9,950 fish were tagged at Seven Bays. Release dates of fish tagged at these two sites in 1996 were April 25 and June 5, respectively.

To maximize angler tag returns, informational posters describing the Monitoring Program's tagging studies were distributed throughout Lake Roosevelt and Rufus Woods Reservoir at locations frequented by anglers. These posters gave a visual description of floy tags and requested that anglers return tags with the following recapture information: recapture date, location, fish length and fish weight. Anglers returning tag information were sent a letter informing them of the fish release date, location, and length of fish at time of release. Anglers returning tags were also provided with a brief summary of the tagging program.

Tag return data was compiled and analyzed to determine fish growth rates and movement within Lake Roosevelt and was also used to estimate entrainment rates through Grand Coulee Dam. Movement was analyzed by noting recapture location and plotting it against release location and date.

2.4 Creel Design and Procedures

A two-stage probability sampling scheme was used to determine annual fishing pressure, catch-per-unit-effort (CPUE), and sport fish catch and harvest by species on Lake Roosevelt (Lambou 1961 and 1966; Malvestuto 1983). Creel surveys were conducted at 48 locations including the Spokane and Colville Tribal campgrounds and National Park Service (NPS) boat launches.

Three creel clerks were employed to interview anglers at access points along Lake Roosevelt. The lake was divided into three sections (upper, middle and lower), and one creel clerk was permanently assigned to each section (Figure 1.1). Each creel clerk was scheduled approximately 21 days per month to make roving instantaneous pressure and effort counts at access points within their section.

Creel schedules were constructed by dividing each month into weekday and weekend/holiday stratum and days were stratified into am. (sunrise to 12:00) and p.m. (12:00 to sunset) time periods. Schedules for roving instantaneous pressure counts were randomly selected on six weekdays and four weekend/holidays, with half of the surveys conducted during the a.m. and the other half conducted during the p.m.. The remaining a.m. or p.m. time slots over the 20 day time period were used to conduct five hour access point surveys. Creel schedules were developed monthly by randomly selecting the time, day, survey type (roving instantaneous pressure count or access point survey) and, in the case of access surveys, the location. Roving instantaneous pressure counts and access point survey schedules differed among creel clerks both spatially and temporally.

During access point surveys, creel clerks collected the following data from each angler interviewed: angler type, hours fished, completed trip, satisfaction, zip code of origin, target species, and number of fish caught and released. Fish harvested were identified to species, measured in millimeters, weighed in grams and examined for floy tags, fin clips, and physical markings such as eroded pectoral and pelvic fins, and stubbed dorsal fins. Physical marks were used to differentiate rainbow trout of net-pen or hatchery origin from wild fish. Scale samples were collected from representative kokanee salmon, rainbow trout, and walleye, and stomach samples were collected from kokanee salmon. Heads were taken from fin clipped kokanee salmon for coded wire tag analysis. Additionally, incoming boaters (angler or non angler) were surveyed to determine the number of boats angling and the number of anglers per boat.

During roving instantaneous pressure counts, each creel clerk recorded the number of boat trailers and shore anglers at the access points in their section. The creel clerk reached the access points by road. No angler interviews were performed during roving instantaneous pressure counts.

Data collected from December, 1995 through November, 1996 were used for 1996 creel analyses. Quarters were established based on historic weather trends and angler use of the fishery as December, 1995 through February, 1996 (winter), March, 1996 through May, 1996 (spring), June, 1996 through August, 1996 (summer), and September, 1996 through November, 1996 (fall). December, 1995 was included in the 1996 creel analyses to allow examination of a continuous rather than a broken (e.g. Jan., Feb. and Dec., 1996) winter quarter. If no anglers were surveyed during any month within any stratum but boat trailers were counted at access points, quarterly averages were used to estimate angler catch, effort, and pressure for that month/stratum.

During 1990 through 1993, air flights (one flight per stratum) were scheduled to coincide with monthly roving instantaneous pressure counts. Creel clerks recorded the number of boat trailers and shore anglers in their section while a surveyor in an airplane concurrently recorded the number of boats on the water and the number of shore anglers. Air-flight information was used to compute a correction factor for the number of boats on the water versus the number of boat trailers at access points as follows:

$$CF_b = \left(\frac{B_a}{B_c}\right)$$

Where:

CF_b = boat trailer correction factor for each stratum per month;

B_a = boat count from air survey for each stratum; and

B_C = number of boat trailers counted by creel clerks during air flights for each stratum.

Correction factors for boat trailers versus boats on the water determined from 1990-1993 (Appendix Tables D. 1 and D.2) were averaged and applied to 1996 data because limited funds negated our ability to conduct regularly scheduled air flights in 1996.

The number of boats on the reservoir was determined for the weekday / weekend strata, reservoir section and month by completing the following calculation:

$$T_b = (C_{bt})(CF_b)$$

Where:

T_b = number of boats on the water for each stratum per month;
C_{bt} = mean boat trailer count from pressure counts for each stratum per month; and
CF_b = boat trailer correction factor for each stratum per month.

The number of boats fishing for the weekday / weekend strata, reservoir section and month was calculated as:

$$B_f = (T_b)(\%B_f)$$

Where:

B_f = number of boats fishing for each stratum per month;
T_b = number of boats on the water for each stratum per month; and
$\%B_f$ = percent of boats fishing for each stratum per month (number is in decimal form).

The adjusted mean number of boat anglers per day for the weekday / weekend strata, reservoir section and month was estimated using the formula:

$$X_d = (Ad)(B_f)$$

Where:

X_d = adjusted mean number of anglers per boat per day for each stratum per month;
Ad = mean number of anglers per boat from effort counts for each stratum per month; and
B_f = number of boats fishing for each stratum per month.

The instantaneous number of boat anglers was estimated separately by section then summed to obtain a full lake estimate.

The number of hours available for fishing (sunrise to sunset) was estimated as:

$$N_s = (D_s)(H_d)$$

Where:

N_s = number of hours per weekend, weekday per month;
D_s = number of days per month a weekday or weekend; and
H_d = average number of hours per day for each stratum per month.

The number of hours sampled for each stratum per month was estimated using the formula:

$$n = \sum_{i=1}^{D_s}(H_{ci})$$

Where:

n = number of hours sampled for each stratum per month;
D_s = number of days per month within each stratum; and
H_{Ci} = mean number of hours creeled per day for each stratum per month.

The mean number of shore anglers per day for each stratum per month was estimated using the formula:

$$X_d = \frac{\sum_{i=1}^{P_d}(S_{pi})}{P_d}$$

Where:

X_d = mean number of shore anglers per day for each stratum per month from pressure counts;
P_d = number of pressure counts conducted for each stratum per month; and
S_{pi} = total number of shore anglers counted during pressure counts for each stratum per month.

The mean number of anglers (boat or shore) for each stratum per month was estimated using the formula:

$$X_s = (X_d)(D_s)$$

Where:

X_s = mean number of anglers for each stratum per month;
X_d = mean number. of anglers for each stratum per day; and
D_s = number of days per month within the stratum.

The standard deviation of anglers (boat or shore) for each stratum per month was estimated using the formula:

$$S_s = (S_d)(D_s)$$

Where:

S_s = standard deviation of anglers for each stratum per month;
S_d = standard deviation of anglers per day for each stratum per month; and
D_s = number of days per month for each stratum per month.

The mean number of angler hours per angler for each stratum was estimated using the formula:

$$H_a = \left(\frac{T_h}{A_i}\right)$$

Where:

H_a = mean number of angler hours per angler for each stratum per month;
T_h = total hours spent fishing for each stratum per month; and
A_i = total number of anglers interviewed for each stratum per month.

Pressure (hours fished) was estimated for day stratum (week day or weekend/holiday) for boat and shore anglers for each month by section by the formula:

$$PE_s = \left(\frac{N_s}{n}\right)(X_s)(H_a)$$

where:

PE_s = pressure estimate for each stratum per month;
N_s = number of hours for each stratum per month;
n = number of hours sampled for each stratum per month;
X_s = mean number of anglers for each stratum per month; and
H_a = mean number of angler hours per angler for each stratum per month.

The variance of the pressure (hours fished) estimate for each stratum per month was calculated by:

$$VPE_s = \left(\frac{N_s}{n}\right)S_s^2$$

where:

VPE_S = variance of pressure estimate for each stratum per month;
N_S = number of hours for each stratum per month;
n = number of hours sampled for each stratum per month; and
S_S = standard deviation of mean number of angler hours for each stratum per month.

Ninety-five percent confidence intervals for each stratum per month were calculated by:

$$C.\ I. = PE \pm 1.96\sqrt{(VPE_s)}$$

where:

$C.I.$ = 95% confidence intervals for each stratum per month;
PE = pressure estimate for each stratum per month; and
VPE_S = variance of the pressure estimate for each stratum per month.

Monthly angler pressure and 95% C.I. was determined for each month by weekend / weekday strata, boat/shore anglers, and reservoir section. If data gaps existed in any strata the quarterly averages were used to fill the gaps. Annual angler pressure and 95% C.I. estimates were calculated by summing monthly angler pressure estimates and 95% C.I. estimates for that section. Each section was added together to get full lake estimates. In 1993 through 1995, confidence intervals for pressure estimates were computed incorrectly, resulting in 84% confidence intervals being reported as 95% confidence intervals. This does not affect confidence intervals reported for years prior to 1993 or those in this report.

Studies by Fletcher (1988) and Malvestuto et al. (1978) have shown that CPUE values calculated independently from complete and incomplete trip data are not statistically different. Therefore, complete and incomplete angler trips were used to compute CPUE for fish species in each stratum. CPUE was calculated independently for fish captured (kept and released) and fish harvested (kept) for each stratum for the month by the formula:

$$CPUE = \left(\frac{F}{T_h}\right)$$

where:

$CPUE$ = Catch per unit effort of a particular fish species for each stratum per month;
F = number of fish captured (harvested) for each stratum per month; and
Th = total hours spent fishing for each stratum per month.

Monthly CPUE of a particular fish species was calculated by dividing the total catch for the entire month (all stratum) by the total angler hours (all stratum) for each section. Annual CPUE values of a particular fish species were calculated by dividing the total catch for the year by the total number of angler hours for the year.

Harvest of fish species was determined for each stratum per month by the formula:

$$Harvest = \left(H_{cpue}\right)\left(PE_s\right)$$

where:

$Harvest$	=	harvest of a particular fish species for each stratum per month;
$Hcpue$	=	number of a particular fish species harvested per unit of effort for each stratum per month; and
PE_S	=	pressure (hours fished estimate for each stratum per month.

Monthly harvest estimates for a particular fish species by stratum were combined to calculate a total monthly harvest estimate by section. Monthly harvest estimates were combined to calculate annual estimates for each fish species by section. Section harvest estimates were added by month to obtain full lake monthly harvest.

Data compiled by the U.S. Fish and Wildlife Service in 1980 and 1985, showed a typical angler spent $23.00/fishing trip in 1980 and $26.00/fishing trip in 1985 in inland waters of Washington State (USFWS 1989). To calculate current dollar amount spent by anglers per trip, the 1985 cost per fishing trip was adjusted for inflation using the regional consumer price index (CPI). The following formula was used:

$$D_{96} = \left(\frac{D_{85} x C_{96}}{C_{85}}\right)$$

where:

$D96$	=	dollar value per fishing trip for the Lake Roosevelt fishery in 1996;
$C85$	=	regional CPI for 1985;
$C96$	=	regional CPI for 1996; and
$D85$	=	dollar value per fishing trip for the Lake Roosevelt fishery in 1985 ($26.00).

The number of angler trips to Lake Roosevelt in 1996 was estimated by dividing the estimated number of angler hours fished by the mean trip length for each section and month. The 1996 dollar value was multiplied by total number of angler trips in 1996 to provide an estimate of the economic value of the fishery. The number of angler trips per month was determined by dividing the total number of angler hours per month by the average length of a completed fishing trip for the month. Annual angler trips were calculated by summing monthly angler trip values.

2.5 Fisheries Surveys and Relative Abundance

Fish were collected from nine index stations in Lake Roosevelt during 1996 (Figure 1.1) to determine their relative abundance. Principle target species included kokanee salmon, rainbow trout, and walleye, although it was assumed that all fish were collected in proportion to their relative abundance in the lake.

Relative abundance surveys were performed in littoral areas and tributaries by electrofishing 10 minute transects using SR- 180 and SR-23 electrofishing boats (Smith Root, Inc., Vancouver, WA) according to procedures outlined by Reynolds (1983) and Novotany and Prigel(1974). Voltage was adjusted to produce a pulsating DC current of approximately 5 amperes. Fish were collected using dip nets and placed into live wells on the boat for examination and data collection. Species and approximate numbers of fish not captured were also recorded. A minimum of six 10 minute transects were performed at each sample station.

Additional relative abundance surveys were performed in pelagic zones with bottom, surface, and vertical monofilament gillnets using methodologies described by Hubert (1983). The following gillnets were used: two horizontal surface set gillnets 61 m in length by 6.1 m deep, with four 15.2 m long panels graded from 1.3 to 7.6 cm stretch mesh; two horizontal bottom set gillnets 61 m in length by 6.1 m deep, with four 15.2 m long panels graded from 1.3 to 8.9 cm stretch mesh; and two vertical gillnets 61 m deep by 3 m wide, with 2 vertical panels. Stretch mesh panels on the two vertical gillnets were 5.1 and 6.4 cm and 7.6 and 10.2 cm, respectively. Gillnets were set in early afternoon (2:00 p.m.) and pulled at approximately 10:00 a.m. the next morning.

Fish captured were identified to species using the taxonomic key of Wydoski and Whitney (1979). Total lengths were measured to the nearest millimeter and scales were removed from target fish species to determine age and growth. Target species were weighed to the nearest gram and sex was determined when possible. Stomach samples were collected from representative sizes of target species. Heads of adipose clipped kokanee salmon were removed and sent to the UCUT Fisheries Research Center at EWU, where coded wire tags were dissected out and examined.

2.6 Age, Back Calculations and Condition Factor

In the field, scales were taken from appropriate locations for each species (Jearld 1983) and placed in coin envelopes labeled with fish number, length, weight, location, date, and species for later analysis. In the laboratory, back-calculation measurements and age class of each fish were determined simultaneously. Scales were placed between two microscope slides and examined using a Realist Vantage.5, Model 33 15 microfiche reader. A single, non-regenerated, uniform scale was selected to determine age and obtain measurements for back calculation of length at age. Age was determined by counting the number of annuli (Jearld 1983). For back calculations, the annulus distance was measured from the origin of the scale to the last circuli of each respective annulus. Each measurement was made under constant magnification to the nearest millimeter.

Lee's back-calculation method was used to determine the length of the fish at the formation of each annulus (Carlander 1950, 1981; Hile 1970). However, due to a small number of samples, fish length at scale formation was assumed to be zero.

Back-calculations were computed using the formula:

$$L_i = a + \left(\frac{L_c - a}{S_c} \right) S_i$$

where:

L_i = length of fish (in mm) at each annulus formation;
a = intercept of the body-scale regression line;
L_c = length of fish (in mm) at time of capture;
S_c = distance (in mm) from the focus to the edge of the scale; and
S_i = scale measurement to each annulus.

A condition factor describing how a fish adds weight in relation to incremental changes in length was determined for each fish (Hile 1970, Everhart and Youngs 1981). The relationship is shown by the formula:

$$K_{TL} = \left(\frac{w}{l^3} \right) 10^5$$

where:

K_{TL} = condition factor;
w = weight of fish (g); and
l = total length of fish (mm).

2.7 Feeding Habits

Fish stomachs were collected from kokanee salmon, rainbow trout, and walleye at each index station. Additional kokanee salmon stomachs were obtained from anglers throughout the year by creel clerks. Stomachs from representative sizes of fish were collected by making an incision into the body cavity, cutting the esophagus, and pinching the pyloric sphincter. The esophagus was clamped to keep prey items from being expelled and the stomach was placed in 10% formalin.

In the laboratory, stomachs were transferred to a 70% isopropyl alcohol solution. Contents were identified and enumerated by taxa using taxonomic keys by Brooks (1957), Ward and Whipple (1966), Borror et al. (1976), Ruttner-Kolisko (1974), Edmonds et al. (1976), Wiggins (1977), Pennak (1989), and Merritt and Cummins (1984). Food organisms were identified using a Nikon SMZ- 10 dissecting microscope equipped with a fiber optic illumination system and a 5 mm ocular micrometer.

Sorted stomach contents were dried at 105° for 24 hours on a stainless steel wire screen and weighed on a Sartorius Model H51 analytical balance to the nearest 0.0001 g (Weber 1973, APHA 1976). Dry weight values were combined for each age class, and annual means and standard deviations were calculated by species and age class.

Index of relative importance (IRI) values were used to compensate for numerical biases that tend to over-emphasize small prey groups consumed in large numbers and weight biases. that overemphasize large prey items consumed in small numbers (Bowen 1983). The IRI (George and Hadley 1979) was calculated using the formula:

$$RI_a = \frac{100 AI_a}{\sum_{a=1}^{n} AI_a}$$

where:

RI_a = relative importance of food item a;
AI_a = absolute importance of food item a (i.e., frequency of occurrence + numerical frequency + weight frequency of food item a); and
n = number of different food types.

IRI values range from 0 to 100, with higher values representing prey items of greater importance in the fish diet.

Diet overlap was calculated to examine the degree of intra- and inter-species competition in Lake Roosevelt. Fish diet overlaps were computed by using the overlap formula of Morisita (1959) as modified by Horn (1966). Overlap values were based upon indices obtained from IRI calculations. Overlap index was expressed by the equation:

$$C_x = \frac{2\sum_{i=1}^{n}\left(P_{xi} x P_{yi}\right)}{\sum_{i=1}^{n} P_{xi}2 + \sum_{i=1}^{n} p_{yi}2}$$

where:

C_x = overlap coefficient;
n = number of food categories;
P_{xi} = proportion of food category (i) in the diet of species x; and
P_{yi} = proportion of food category (i) in the diet of species y.

Overlap coefficients range from 0 (no overlap) to 1 (complete overlap). Values of less than 0.3 are considered low and values greater than 0.7 indicate high overlap (Peterson and Martin-Robichaud 1982). High diet overlap indices may indicate competition only if food items utilized by the species are limited (MacArthur 1968).

Dietary analysis also included calculation of electivity indices to examine size selectivity of zooplankton by kokanee salmon and rainbow trout during 1996. Electivity values were computed using Ivlev's (1961) equation as modified by Strauss (1979):

$$L = r_i - p_i$$

where:

L = the measure of food selection;
r_i = the relative abundance of various size classes of prey species i in the gut; and
p_i = the relative abundance of various size classes of prey species i in the environment.

Electivity index values range from +l to -1, with values near zero indicating that prey is being consumed in proportion to its abundance in the environment. Positive values indicate selection for particular prey sizes, while negative values indicate avoidance of particular size classes of prey.

3.0 RESULTS

3.1 Hydrology

3.1.1 Reservoir Operations

During 1996, runoff in the Columbia River Basin above Grand Coulee Dam was 125% of normal from January through July, resulting in an increased influence of flood control strategies in determining reservoir operations. Mean monthly Lake Roosevelt elevations for 1996 began at 1,28 1.7 feet above mean sea level in January, dropped to a yearly minimum of 1,232.3 feet in May, and refilled to near full pool by July (Table 3.1 and Figure 3.1). For the remainder of the year, reservoir elevations were held relatively stable within twelve feet of full pool (Figure 3.1). Mean reservoir elevation in 1996 was 1,27 1.4 feet above mean sea level (Table 3.1). Mean monthly outflows at Coulee Dam during 1996 ranged from 90.7 kcfs in October to 173.1 kcfs in June, with a yearly mean of 134.8 kcfs (Table 3.1). During 1996, spill contributed to the total outflow from Lake Roosevelt for the first time since the inception of this monitoring program (1988). Mean monthly spill ranged from 0.0 kcfsd (January, October-December) to 15.1 kcfsd in June, 1996 (Table 3.1). Mean monthly inflows during. 1996 ranged from 94.7 kcfs in November to 243.2 kcfs in June, with a yearly mean of 143.5 kcfs (Table 3.1). Mean monthly water retention times ranged from 15.7 days in May to 49.2 days in October (Table 3.1). Average water retention times in Lake Roosevelt remained below 34 days from January through July but exceeded 40 days by September (Table 3.1). The maximum daily water retention time for 1996 was 83.6 days on February 8, and the minimum was 13.4 days on April 30 (Figure 3.1).

3.1.2 Water Quality

Monthly reservoir temperatures at 12 m (chosen to avoid surface variations and found to be most representative of mean temperatures in vertical profiles) ranged from 2.2 °C at Gifford in March to 20.0 °C at Spring Canyon in July (Appendix C). pH ranged from 7.02 in March at Porcupine Bay to 9.4 at Seven Bays in December, 1996 (Appendix C). Dissolved oxygen readings ranged from 5.3 mg/L at 33 m at Porcupine Bay during August to 20.2 mg/L at the surface of Porcupine Bay during March (Appendix C). Conductivity readings ranged between 0.056 mmho/cm at 15 m in May at Porcupine Bay and 0.211 mmho/cm at 15 m depth at Porcupine Bay in November (Appendix C). Oxidative reductive potential ranged from 172 mV in March at Keller Ferry to 455 mV in November at

Table 3.1 **Monthly and annual means for reservoir inflow, outflow, spill, reservoir elevation, storage volume, and water retention time for Lake Roosevelt in 1996.**

Month	Inflow (kcfs)	Outflow (kcfs)	Spill (kcfsd)	Reservoir Elevation (Ft)	Storage Capacity (kcfsd)	Water Retention Time (Days)
Jan 1996	148.5	154.9	0.0	1,281.7	4,261.2	28.4
Feb 1996	167.3	154.9	12.9	1,280.9	4,227.0	31.7
Mar 1996	125.1	144.4	12.5	1,258.5	3,424.0	23.9
Apr 1996	153.0	147.7	14.7	1,235.1	2,679.1	18.6
May 1996	196.0	167.8	10.9	1,232.3	2,597.9	15.7
Jun 1996	243.2	173.1	15.1	1,267.8	3,752.3	21.8
Jul 1996	174.4	57.9	1.5	1,287.9	4,508.1	29.4
Aug 1996	130.2	131.2	0.3	1,284.9	4,392.5	34.3
Sep 1996	97.2	90.8	0.1	1,280.7	4,219.2	47.9
Oct 1996	96.9	90.7	0.0	1,284.1	4,352.8	49.2
Nov 1996	94.7	93.9	0.0	1,284.2	4,355.5	48.3
Dee 1996	98.3	110.7	0.0	1,278.5	4,042.2	38.9
Mean 1996	**143.5**	**140.5**	**5.6**	**1,271.4**	**3,907.8**	**31.7**

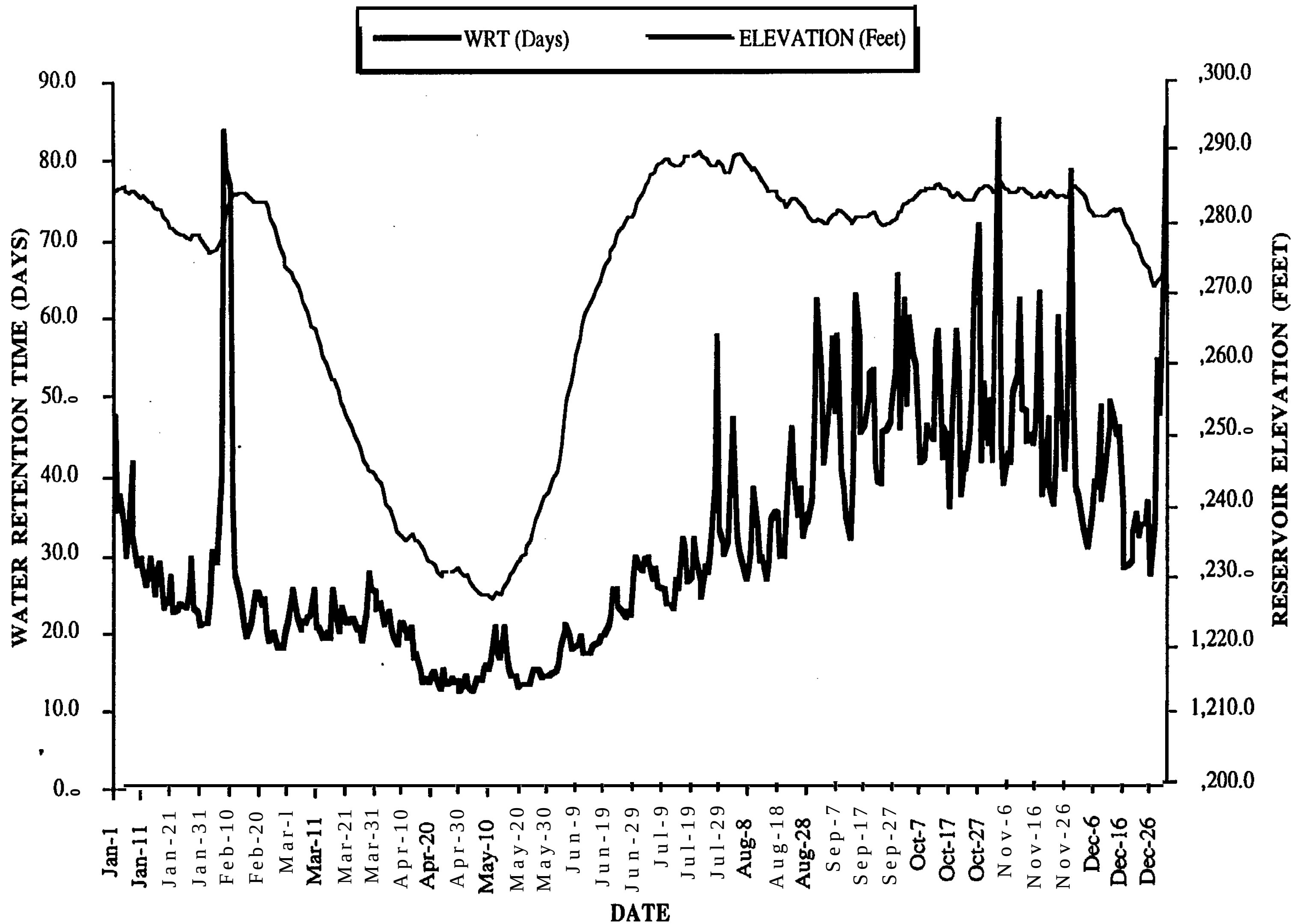


Figure 3.1 **Daily water retention times (days), plotted against daily reservoir elevations (feet), for Lake Roosevelt in 1996 .**

Gifford (Appendix C). Monthly secchi disk depths ranged from 0.2 m in May at the San Poil River, to 11.5 m in September at Keller Ferry. Keller Ferry had the highest yearly average secchi disk readings of 5.2 m, while Porcupine Bay had the lowest average of 3.3 m (Appendix C).

3.2 Zooplankton

3.2.1 Species Identified

A total of 10 species of zooplankton were identified from Lake Roosevelt during the 1996 sampling period . Six species were identified from the Order Cladocera and included. *Daphnia galeata mendotae, D. retrocurva, D. pulex, Diaphanosoma brachynun, Bosmina longirostris* and *Leptodora kindtii.* (Table *3.2).* A review of Lake Roosevelt *Daphnia* species by Dr. Ross Black and Stephen Lewis (EWU) determined that *D. pulex* were incorrectly identified *as D. schødleri* in previous years. Four species were identified from the Order Eucopepoda during 1996 including *Leptodiaptomus ashlandi, Epischura nevadensis, Diacyclops bicuspidatus thomasi,* and *Mesocyclops edax* (Table 3.2). As in previous years, rotifers were not enumerated in 1996.

3.2.2 Daphnia Species Densities

Daphnia spp. densities in Lake Roosevelt remained low from March through June 1996, with most sites averaging below 10 organisms/m3 (Tables 3.3 - 3.12). By June, *Daphnia* spp. densities began to increase at Porcupine Bay, Seven Bays, Keller Ferry and Spring Canyon, reaching yearly maximum densities in either July (Seven Bays, 8,235/m^3; and Spring Canyon; 8,257/m^3), August (Keller Ferry; 8,679/m^3), or October (Porcupine Bay, 8,534/m^3). *Daphnia* spp. densities began to increase in July at Gifford, reaching peak densities by September (2,644/m^3; Table 3.4). The highest recorded monthly *Daphnia* spp. density for 1996 was 7,214.g organisms/m3 in the San Poil River arm during October, followed by a value of 5,362.7 organisms/m3 at Porcupine Bay in the same month. Yearly average densities of *Daphnia* spp. ranged from 267.6 organisms/m3 at Gifford (Table 3.4) to 1,414.7 organisms/m3 at Porcupine Bay (Table 3.6). Porcupine Bay was the only sampling location that exhibited a double peak in zooplankton abundance during 1996 - one occurring in July and the other in October (Table 3.6).

Table 3.2 Synoptic list of zooplankton taxa historically identified in Lake Roosevelt including those identified during the 1996 study period.

Phylum Anthropoid
Class Crustacea
Subclass Brachiopoda
Order Cladocera
Family Daphnidae
1. *Ceriodaphnia quadranqula*
2. *Daphnia galeata mendotae**
3. *Daphnia retrocurva**
4. *Daphnia pulex* [1]*
5. *Daphnia thorata*
6. *Simocephalus serrulatus*

Family Chydoridae
7. *Alona guttata*
8. *Alona quadrangularis*
9. *Chydorus sphaericus*

Family Sididae
10. *Diaphanosoma brachyurum**
11. *Diaphanosoma birgei*
12. *Sida crystallina*

Family Bosminidae
13. *Bosmina Longirostris**

Family Leptodoriidae
14. *Leptodora kindtii**

Subclass Copepoda
Order Eucopepoda
Suborder Calanoida
Family Diaptomidae
15. *Leptodiaptomus ashlandi**
16. *Skistodiaptomus oregonensis*

Family Temoridae
17. *Epischura nevadensis**

Suborder Cyclopoida
Family Cyclopoidae
18. *Diacyclops bicuspidatus thomasi**
19. *Mesocyclops edax**

Suborder Harpacticoida
Family Harpacticoidae
20. *Bryocamptus* spp.

Phylum Rotifera
Class Monogononta
Order Flosculariacea
Family Conochilidae
21. *Conochilus unicomis*

Family Testudinellidae
22. *Testudinella* spp.

Family Filiniidae
23. *Filinia terminalis*

Order Plioma
Family Synchaetidae
24. *Pleosoma truncatum*
25. *Poryarrhra* spp.
26. *Synchaeta pectinata*

Family Asplanchnidae
27. *Asplanchna herricki*
28. *Asplanchna priodonta*

Family Brachionidae
29. *Brachionus quadridentata*
30. *Kellicottia longispina*
31. *Keratella* spp.
32. *Notholca* spp.

Family Epiphanidae
33. *Epiphanes* spp.

Family Euchlanidae
34. *Euchlanis dilatata*
35. *Euchlanis triquetra*

Family Trichotriidae
36. *Trichotria tetractis*

Family Trichocercidae
37. *Trichocerca spp.*

Family Lecanidae
38. *Monostyla lunaris*

* Indicates that this species was observed in 1996.
1 *D. pulex* was identified *as D. schødleri* in previous years.

Table 3.3 **Mean densities (#/m^3) and standard deviations for representative zooplankton at Kettle Falls (Index Station 1), in 1996.**

	Dapbnia	Leptodora	Cladocera	Copepoda	Nauplii	Total Zooplankton
May	0.2 ± 0.4	0.0 ± —	0.6 ± 0.6	61.3 ± 14.3	4.8 ± 5.0	66.7 ± 19.3
Jul	0.0 ± —	0.0 ± —	395.5 ± 41.4	480.2 ± 19.9	224.4 ± 58.0	1,100.l ± 84.3
Oct	100.0 ± 5.5	0.3 ± 0.6	191.9 ± 8.6	23.7 ± 10.4	1.0 ± 0.5	216.6 ± 17.8
Mean	**33.4 ± 2.0**	**0.1 ± 0.2**	**196.0 ± 16.9**	**188.4 ± 14.9**	**76.7 ± 21.2**	**461.1 ± 40.5**

Table 3.4 **Mean densities (#/m^3) and standard deviations for representative zooplankton at Gifford (Index Station 2), in 1996.**

	Daphnia	Leptodora	Cladocera	Copepoda	Nauplii	Total Zooplankton
Mar	**0.0** ± —	**0.0** ± —	0.5 ± 0.5	40.1 ± 4.2	1.2 ± 0.7	41.8 ± 5.1
Apr	0.3 ± 0.3	0.0 ± —	0.5 ± 0.0	4.3 ± 0.7	0.5 ± 0.5	5.2 ± 0.3
May	0.7 ± 0.6	0.0 ± —	1.0 ± 1.0	73.7 ± 3.5	4.7 ± 2.1	79.4 ± 4.6
Jun	0.5 ± 0.5	0.0 ± —	2.3 ± 0.6	188.9 ± 29.7	15.1 ± 2.5	206.3 ± 32.7
Jui	18.4 ± 3.2	0.0 ± —	204.2 ± 30.7	1,159.0 ± 125.4	515.1 ± 104.9	**1,878.3** ± 145.4
Aug	209.7 ± 52.7	0.0 ± —	209.7 ± 52.7	445.2 ± 290.8	64.4 ± 15.9	719.3 ± 226.2
Sep	**1,615.3** ± 77.3	1.8 ± —	1,641.0 ± 66.5	980.6 ± 64.0	22.1 ± 11.0	**2,643.7** ± 100.7
Oct	815.0 ± 162.8	0.0 ± —	**1,326.4** ± 201.3	51.5 ± **49.8**	22.1 ± 5.5	1,400.0 ± 199.3
Nov	12.6 ± 1.6	0.0 ± —	12.8 ± 1.4	11.1 ± 2.6	0.5 ± 0.0	24.3 ± 3.9
Dec	3.0 ± 0.9	0.0 ± —	3.0 ± 0.9	7.1 ± 2.2	0.2 ± 0.3	10.3 ± 2.6
Mean	267.6 ± **30.0**	**0.2** ± - -	**340.1 ± 35.6**	**296.2 ± 57.3**	**64.6 ± 14.3**	**700.9 ± 72.1**

Table 3.5 **Mean densities (#/m^3) and standard deviations for representative zooplankton at Hunters (Index Station 3), in 1996.**

	Daphnia	Leptodora	Ciadocera	Copepoda	Nauplii	Total Zooplankton
May	1.7 ± 1.2	0.0 ± —	2.7 ± 2.1	87.5 ± 23.5	10.8 ± 5.2	100.9 ± 25.5
Jul	171.1 ± 81.3	230.0 ± 114.5	629.2 ± 219.9	5,548.6 ± 681.7	255.7 ± 64.0	6,433.5 ± 943.2
Oct	894.1 ± 72.4	33.1 ± —	1,148.0 ± 107.7	106.7 ± 19.4	18.4 ± 8.4	1,273.1 ± 105.6
Mean	**355.6 ± 51.6**	**87.7 ± 38.2**	**593.3 ± 109.9**	**1,914.3 ± 214.5**	**95.0 ± 25.9**	**2,602.5 ± 358.1**

Table 3.6 **Mean densities (#/m^3) and standard deviations for representative zooplankton at Porcupine Bay (Index Station 4), in 1996.**

	Daphnia	Leptodora	Cladocera	Copepoda	Nauplii	Total Zooplankton
Mar	0.0 ± —	0.0 ± —	3.8 ± 1.9	141.5 ± 24.0	2.9 ± 1.7	148.2 ± 25.2
Apr	5.9 ± 0.7	0.0 ± —	8.4 ± 1.0	120.7 ± 20.0	27.1 ± 5.8	156.2 ± 22.1
May	1.4 ± 0.6	0.0 ± —	1.4 ± 0.6	90.5 ± 2.5	10.1 ± 7.6	101.9 ± 8.6
Jun	220.8 ± 38.6	1.8 ± 3.2	224.4 ± 35.5	6,801.4 ± 272.4	143.5 ± 91.2	7,169.3 ± 341.1
Jul	3,547.0 ± 234.6	123.3 ± 31.4	3,776.9 ± 311.9	6,039.8 ± 3.2	42.3 ± 44.6	9,859.0 ± 270.9
Aug	1,569.3 ± 147.7	0.0 ± —	1,582.2 ± 165.1	2,982.2 ± 479.8	18.4 ± 8.4	4,582.7 ± 338.0
Sep	386.3 ± 103.1	3.7 ± 6.4	423.1 ± 120.0	2,152.5 ± 137.3	14.7 ± 13.9	2,590.3 ± 225.3
Oct	5,362.7 ± 517.8	1.8 ± 3.2	5,463.9 ± 502.2	3,055.8 ± 55.3	14.7 ± 3.2	8,534.4 ± 466.0
Nov	833.4 ± 312.2	0.0 ± —	835.2 ± 312.3	853.6 ± 202.4	29.4 ± 11.5	1,718.3 ± 375.2
Dec	2,220.5 ± 98.2	0.0 ± —	2,220.5 ± 98.2	1,387.1 ± 369.4	75.4 ± 39.2	3,683.1 ± 504.9
Mean	**1,414.7 ± 145.4**	**13.1 ± 4.4**	**1,254.0 ± 154.9**	**2,362.5 ± 156.6**	**37.9 ± 22.7**	**3,854.3 ± 257.7**

Table 3.7 **Mean densities (#/m^3) and standard deviations for representative zooplankton at the confluence of the Spokane River with the main stem Columbia (Index Station Confluence), in 1996.**

	Daphnia	Leptodora	Cladocera	Copepoda	Nauplii	Total Zooplankton
Mar	0.0 ± —	0.0 ± —	2.1 ± 0.7	174.8 ± 24.5	10.1 ± 4.0	187.0 ± 28.6
Apr	0.3 ± 0.3	0.0 ± —	0.3 ± 0.3	119.7 ± 14.6	25.7 ± 5.5	145.7 ± 20.3
Jun	3.7 ± 3.2	0.0 ± —	11.0 ± 5.5	4,374.8 ± 209.6	134.3 ± 30.4	4,520.2 ± 244.2
Aug	1,170.8 ± 121.3	25.5 ± 15.3	1,201.4 ± 130.4	3,097.7 ± 435.0	15.3 ± 8.8	4,314.3 ± 370.1
Sep	1,473.6 ± 52.7	16.6 ± 5.5	1,501.2 ± 58.2	1,788.2 ± 132.5	0.0 ± —	3,289.4 ± 110.2
Nov	1,256.5 ± 228.7	0.0 ± —	1,273.1 ± 214.6	244.7 ± 100.2	0.0 ± —	1,517.8 ± 215.1
Dec	1,068.9 ± 200.3	0.0 ± —	1,083.6 ± 186.9	1,179.3 ± 96.0	316.4 ± 33.3	2,579.3 ± 227.1
Mean	**710.5 ± 86.6**	**6.0 ± 3.0**	**724.7 ± 85.2**	**1,569.5 ± 144.6**	**71.7 ± 11.7**	**2,364.8 ± 173.7**

Table 3.8 **Mean densities (#/m^3) and standard deviations for representative zooplankton at Seven Bays (Index Station 6), in 1996.**

	Daphnia	Leptodora	Cladocera	Copepoda	Nauplii	Total Zooplankton
Mar	0.0 ± —	0.0 ± —	1.1 ± 0.4	144.4 ± 54.2	5.9 ± 5.5	151.4 ± 60.0
Apr	3.1 ± 0.8	0.0 ± —	4.4 ± 1.0	135.9 ± 16.0	14.1 ± 2.4	154.4 ± 15.3
May	5.1 ± 2.9	2.8 ± 2.8	64.0 ± 13.1	528.2 ± 71.8	114.6 ± 15.9	706.8 ± 90.1
Jun	360.6 ± 32.8	1.4 ± 2.0	395.1 ± 41.1	3,225.0 ± 572.4	149.5 ± 36.2	3,769.6 ± 557.6
Jul	1,894.9 ± 17.7	99.3 ± 22.1	2,020.0 ± 30.7	6,212.7 ± 197.2	1.8 ± 3.2	8,234.5 ± 178.9
Aug	1,393.6 ± 197.3	13.8 ± 8.9	1,421.2 ± 197.7	2,783.5 ± 430.6	34.0 ± 19.6	4,238.7 ± 578.8
Sep	2,544.3 ± 998.5	0.0 ± —	2,676.8 ± 1,002	3,081.5 ± 915.4	99.3 ± 92.2	5,857.6 ± 1,995
Nov	2,194.8 ± 216.1	0.0 ± —	2,229.7 ± 216.0	355.1 ± 75.3	0.0 ± —	2,584.8 ± 250.3
Dec	93.6 ± 97.7	0.0 ± —	93.6 ± 97.7	105.5 ± 98.0	11.4 ± 5.5	210.4 ± 200.5
Mean	943.3 ± 173.8	13.0 ± 4.0	989.5 ± 177.7	1,841.3 ± 270.1	47.8 ± 20.1	2,878.7 ± 436.3

Table 3.9 **Mean densities (#/m^3) and standard deviations for representative zooplankton at Keller Ferry (Index Station 7), in 1996. .**

	Daphnia	Leptodora	Cladocera	Copepoda	Nauplii	Total Zooplankton
Mar	**0.0** ± —	**0.0** ± —	0.2 ± 0.3	61.0 ± 5.7	2.1 ± 0.9	63.2 ± 4.9
Apr	**0.8** ± 0.1	**0.0** ± —	1.7 ± 0.9	308.4 ± 20.1	44.7 ± 11.5	354.8 ± 13.1
May	45.1 ± 8.5	14.7 ± 7.0	148.1 ± 54.5	1,403.7 ± 230.6	532.6 ± 149.4	2,084.4 ± 242.0
Jun	56.1 ± 6.4	2.8 ± 4.8	118.7 ± 22.5	3,391.5 ± 763.4	642.1 ± 139.7	4,152.2 ± 734.8
Jul	1,039.4 ± 195.9	9.2 ± 8.4	1,048.6 ± 204.2	4,671.0 ± 305.9	35.0 ± 13.9	5,754.6 ± 469.8
Aug	2,615.6 ± 243.7	17.5 ± 5.5	2,647.3 ± 243.6	5,990.1 ± 387.4	41.4 ± 12.6	8,678.8 ± 492.4
Sep	2,040.2 ± 56.6	14.7 ± 13.9	2,055.0 ± 65.9	4,676.5 ± 264.5	60.7 ± 30.7	**6,792.2** ± 322.5
Oct	1,677.8 ± 251.5	0.0 ± —	1,720.1 ± 238.7	5,831.9 ± 333.1	40.5 ± 12.8	**7,592.5** ± 395.2
Nov	237.3 ± 77.3	0.0 ± —	263.1 ± 75.3	**1,412.9** ± 67.1	3.7 ± 6.4	**1,679.7** ± 39.2,
Dec	333.0 ± 37.6	0.0 ± —	401.1 ± 36.8	616.3 ± 11.5	51.5 ± 8.4	**1,068.9** ± 24.9
Mean	804.5 ± 87.8	5.9 ± 4.0	840.4 ± 94.3	**2,836.3** ± 238.9	**145.4** ± 38.6	**3,822.1** ± 273.9

Table 3.10 **Mean densities (#/m³) and standard deviations for representative zooplankton at SanPoil (Index Station 8), in 1996.**

	Daphnia	Leptodora	Cladocera	Copepoda	Nauplii	Total Zooplankton
May	206.4 ± 78.6	4.5 ± 3.9	574.2 ± 155.0	1,112.5 ± 219.7	293.8 ± 120.8	1,980.5 ± 467.7
Jul	4,071.3 ± 512.9	99.3 ± 63.7	4,172.5 ± 560.2	6,001.1 ± 157.5	35.0 ± 13.9	10,208.5 ± 725.8
Oct	7,214.9 ± 439.0	0.0 ± —	7,214.9 ± 439.0	8,808.5 ± 562.0	16.6 ± 23.4	16,039.9 ± 99.5
Mean	**3,830.9 ± 343.5**	**34.6 ± 22.5**	**3,987.2 ± 384.7**	**5,307.4 ± 313.0**	**115.1 ± 52.7**	**9,409.6 ± 431.0**

Table 3.11 **Mean densities (#/m³) and standard deviations for representative zooplankton at Spring Canyon (Index Station 9), in 1996.**

	Daphnia	Leptddora	Cladocera	Copepoda	Naupiii	Total Zooplankton
Mar	0.2 ± 0.3	0.0 ± —	1.2 ± 0.6	136.5 ± 21.5	9.7 ± 3.5	147.4 ± 23.2
Apr	3.1 ± 0.8	0.0 ± —	4.4 ± 1.0	135.9 ± 16.0	14.1 ± 2.4	154.4 ± 15.3
May	10.4 ± 6.8	13.0 ± 0.4	28.4 ± 7.5	704.0 ± 55.1	237.8 ± 94.0	970.1 ± 98.3
Jun	282.4 ± 105.2	2.8 ± 4.8	368.9 ± 91.0	4,768.5 ± 932.7	52.4 ± 12.7	5,189.8 ± 940.8
Jul	3,657.3 ± 730.2	60.7 ± 5.5	3,729.1 ± 743.2	4,509.1 ± 695.6	18.4 ± 23.0	8,256.6 ± 1,451.7
Aug	2,765.5 ± 73.9	27.1 ± 18.6	2,801.0 ± 91.7	5,405.5 ± 674.6	34.5 ± 21.5	8,241.0 ± 636.2
Sep	2,485.4 ± 291.5	27.6 ± 19.1	2,520.4 ± 285.8	5,690.2 ± 1,202.9	40.5 ± 65.4	8,251.1 ± 1,358.7
Oct	390.0 ± 131.3	0.0 ± —	421.3 ± 120.0	2,873.6 ± 476.9	95.7 ± 49.8	3,390.6 ± 637.4
Nov	90.2 ± 94.4	0.0 ± —	128.8 ± 80.4	971.4 ± 216.8	69.9 ± 6.4	1,170.1 ± 297.3
Dec	2,798.2 ± 524.7	0.0 ± —	2,847.9 ± 544.2	2,365.9 ± 653.7	16.6 ± 0.0	5,230.3 ± 1,162.8
Mean	**1,248.3 ± 195.9**	**13.1 ± 4.8**	**1,285.1 ± 196.5**	**2,756.1 ± 494.6**	**59.0 ± 27.9**	**4,100.1 ± 662.2**

Table 3.12 **Mean densities (#/m^3) and standard deviations for representative zooplankton at Rufus Woods (Index Station 10), in 1996.**

	Daphnia	Leptodora	Cladocera	Copepoda	Nauplii	Total Zooplankton
Mar	0.1 ± 0.1	0.0 ± —	0.6 ± 0.4	149.6 ± 8.2	10.0 ± 7.0	160.2 ± 15.3
Apr	2.9 ± 0.7	0.0 ± —	4.0 ± 0.5	88.2 ± 20.0	11.9 ± 3.6	104.1 ± 23.1
May	5.6 ± 2.6	1.9 ± 2.6	41.1 ± 31.7	534.6 ± 31.7	185.0 ± 7.9	760.7 ± 7.9
Jun	93.5 ± 10.6	0.0 ± —	162.6 ± 13.2	3,628.0 ± 124.2	48.6 ± 0.0	3,839.2 ± 137.5
Aug	977.6 ± 277.6	7.5 ± 2.6	987.8 ± 284.2	1,227.1 ± 363.5	3.7 ± 0.0	2,218.7 ± 370.1
Sep.	801.9 ± 515.5	0.0 ± —	801.9 ± 515.5	1,095.3 ± 153.3	16.8 ± 13.2	1,914.0 ± 655.6
Nov	35.2 ± 1.2	0.0 ± —	35.2 ± 1.2	260.4 ± 2.9	2.0 ± 0.5	297.6 ± 2.1
Dec	1,600.0 ± 613.3	0.0 ± —	1,663.5 ± 592.1	1,572.0 ± 547.2	37.4 ± 31.7	3,272.9 ± 1,107.6
Mean	439.6 ± 177.7	1.2 ± 0.7	462.1 ± 179.9	1,069.4 ± 156.4	39.4 ± 8.0	1,570.9 ± 289.9

3.2.3 Total Zooplankton Densities

Total zooplankton densities in Lake Roosevelt remained relatively low at all sites during the March through May portion of the 1996 sampling season (Tables 3.3 -3.12). Total zooplankton densities for this period ranged from a low of 5.2 organisms/m3 at Gifford in April to a high of 2,084.4 organisms/m^3 in May at Keller Ferry (Tables 3.3 - 3.12). Total zooplankton abundance at Spring Canyon, Keller Ferry and Seven Bays began to increase in May (Tables 3.8, 3.9, and 3.11). For these sites, yearly maximum total zooplankton densities were reached in either July (Spring Canyon and Seven Bays; Tables 3.8 and 3.1 l), or August (Keller Ferry; Table 3.9). Gifford and Porcupine Bay total zooplankton densities did not increase until June (Table 3.4 and Table 3.6) reaching maximum yearly densities in September and July, respectively. Total zooplankton densities were high at most sites from May through October, and generally declined somewhat in November or December (Tables 3.3 - 3.12). The highest total zooplankton density for 1996 occurred at the San Poil River in October, where a value of 16,039.9 organisms/m3 was recorded (Table 3.10).

Mean total zooplankton densities at Kettle Falls ranged from 66.7 organisms/m3 in May, to 1,100.l organisms/m3 in July, yielding an annual mean of 461.1 organisms/m3 (Table 3.3). Mean total zooplankton densities at Gifford ranged from 5.2 organisms/m3 in April, to 2643.7 organisms/m3 in September, with an estimated annual mean of 700.9 organisms/m^3 (Table 3.4). Mean total zooplankton densities at Hunters ranged from 100.9 organisms/m3 in May, to 6,433.5 organisms/m3 in July, with a mean of 2,602.5 organisms/m3 (Table 3.5). Porcupine Bay values ranged from 101.9 organisms/m3 in May, to 9,859.0 organisms/m3 in July, with an annual mean of 3,854.3 organisms/m3 (Table 3.6). At the confluence of the Spokane River with the main-stem Columbia, densities ranged from 145.7 organisms/m3 in April, to 4,520.2 organisms/m3 in June, yielding a yearly average of 2,364.8 organisms/m3 (Table 3.7). Seven Bays densities ranged from a low of 15 1.4 organisms/m^3 in March, to a maximum of 8,234.5 organisms/m3 in July, with an annual mean of 2,878.7 organisms/m3 (Table 3.8). Mean total zooplankton densities at Keller Ferry ranged from 63.2 organisms/m^3 in March, to 8,678.8 organisms/m3 in August, with an annual average of 3,822.l organisms/m3 (Table 3.9). Mean total zooplankton densities at San Poil ranged from 1,980.5 organisms/m3 in May, to 16,039.9 organisms/m3 in October, resulting in an annual mean of 9,409.6 organisms/m^3 (Table 3.10). Mean total densities at Spring Canyon ranged from a yearly low of 147.4 organisms/m3 in March, to a maximum of 8,256.6 organisms/m^3 in June, resulting in a yearly mean of 4,100-l organisms/m^3 (Table 3.11). Rufus Woods mean total zooplankton densities ranged from 104.1 organisms/m3 in April, to 3,839.2 organisms/m3 in June, with an annual mean of 1,570.9 organisms/m3 (Table 3.12).

Our data suggests that entrainment rates of zooplankton increase under higher flows and more severe drawdown conditions, and that differences in entrainment rates are most pronounced during the spring. In 1995, runoff estimates above Grand Coulee Dam (January through July) were 103% of the historical average, and we estimated a mean annual zooplankton entrainment rate of 38.2% (Table 3.13). In contrast, 1996 runoff volumes were 125% of normal (January through July) and our estimate of mean annual zooplankton entrainment from Lake Roosevelt was 63.1% (Table 3.13). Our mean estimate of zooplankton entrainment in spring (March through June), 1995 was 48.2%, whereas in 1996 we estimated 82.1% entrainment during the same period (Table 3.13). Differences in entrainment estimates between years were less pronounced during the late summer (August / September). We estimated zooplankton entrainment rates at 18.1% during late summer in 1995, and 25.1% during the same period in 1996 (Table 3.13).

Table 3.13 Estimated entrainment rates of zooplankton, calculated as the percentage of Spring Canyon total zooplankton densities observed at Rufus Woods in 1995 and 1996.

MONTH	1995	1996
March	81.3%	108.7%
April	58.8%	67.4%
May	29.6%	78.4%
June	23.2%	74.0%
August	20.0%	26.9%
September	16.3%	23.2%
Mean Entrainment Rates		
All Months	38.2%	63.1%
March - June	48.2%	82.1%
August - September	18.1%	25.1%

3.2.4 Zooplankton Biomass

Total Cladocera biomass at Kettle Falls averaged 0.1 mg/m^3 and ranged from 0.0 mg/m^3 in July to 0.4 mg/m^3 in October (Table 3.14). Gifford biomass value's averaged 3.5 mg/m^3 for the year and ranged from 0.0 mg/m^3 in March to 28.0 mg/m^3 in September (Table 3.15). Total Cladocera biomass at Hunters averaged 5.7 mg/m^3 and ranged from <0.1 mg/m^3 in May to 12.1 mg/m^3 in October (Table 3.16). Porcupine Bay values averaged 54.5 mg/m^3 for the year and ranged from 0.0 mg/m^3 in March to 182.6 mg/m^3 in October (Table 3.17). The Confluence site had an average biomass of 18.1 mg/m^3 and ranged from 0.0 mg/m^3 in March to 36.4 mg/m^3 in November (Table 3.18). Total Cladocera biomass at Seven Bays averaged 14.1 mg/m^3 for the year and ranged from 0.0 mg/m^3 in March to 36.3 mg/m^3 in November (Table 3.19). Keller Ferry total Cladocera biomass ranged from 0.0 mg/m^3 in March to 85.7 mg/m^3 in September with an average of 19.2 mg/m^3 (Table 3.20). San Poil total Cladocera biomass ranged from 2.5 mg/m^3 in May, to 207.6 mg/m^3 in October, with a mean of 111.9 mg/m^3 (Table 3.21). Spring Canyon total Cladocera -biomass values ranged from <0. 1 mg/m^3 in March and April to 103.2 mg/m^3 in July yielding an average of 33.1 mg/m^3 (Table 3.22). Rufus Woods total Cladocera biomass values averaged 13.7 mg/m^3 and ranged from <0.1 mg/m^3 in March, April and May to 5 1.5 mg/m^3 in December (Table 3.23).

3.2.5 Zooplankton Lengths

Mean lengths of select Cladocera measured in 1996 at Kettle Falls were: *Daphnia* retrocurva - 0.7 *mm; Daphnia pulex - 0.8 mm;* and *Leptodoru kindtii* - 6.0 mm (Table 3.24). Mean lengths at Gifford were: *Daphnia retrocurva - 0.8 mm; Daphnia pulex - 0.8 mm;* and *Leptodoru kindtii* - 6.0 mm Table 3.24). Mean lengths at Hunters were: *Daphniu retrocurva - 0.8 mm; Duphnia pulex - 0.9 mm;* and *Leptodora kindtii* - 5.1 mm (Table 3.24). Mean lengths at Porcupine Bay were: *Daphnia galeata mendotae* - 2.1 mm; *Daphnia retrocurva* - 1.1 *mm; Duphnia pulex* - 1.3 *mm;* and *Leptodora kindtii - 4.6 mm* (Table 3.24). Mean lengths at the Confluence site were: *Daphnia retrocurva* - 1.1 mm; *Daphnia pulex* - 1.3 *mm;* and *Leptodora kindtii - 5.9 mm* (Table 3.24). Mean lengths at Seven Bays were: *Daphnia galeata mendotae* - 1.0 *mm; Daphnia retrocurva - 0.9 mm; Duphnia pulex* - 1.1 *mm;* and *Leptodora kindtii* - 5.1 mm (Table 3.24). Mean lengths at Keller Ferry were: *Duphnia retrocurva* - 1.0 mm; *Daphnia pulex* - 1.1 mm; and *Leptodora kindtii* - 4.7 mm (Table 3.24). Mean lengths at San Poil were: *Duphnia retrocurva* - 1.3 *mm; Daphnia pulex* - 1.3 *mm;* and *Leptodoru kindtii* - 6.0 mm (Table

Table 3.14 **Monthly and yearly mean zooplankton biomass values in mg/m^3 at Kettle Falls (Index Station l), in 1996.**

	May	Jul	Oct	Mean
Daphnia Spp.	<0.1	0.0	*0.4*	**0.1**
Leptodora kindtii	0.0	0.0	<0.1	**<0.l**
Total Cladocera	<0.1	0.0	*0.4*	**0.1**

Table 3.15 **Monthly and yearly mean zooplankton biomass values in mg/m^3 at Gifford (Index Station 2), in 1996.**

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Daphnia Spp.	0.0	<0.1	<.01	<0.1	<.01	0.8	27.9	6.4	0.1	<0.1	3.5
L. kindtii	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	*<0.1*
Total Cladocera	**0.0**	<0.1	<0.1	<0.1	<0.1	0.8	28.0	6.4	0.1	<0.1	3.5

Table 3.16 **Monthly and yearly mean zooplankton biomass values in mg/m^3 at Hunters (Index Station 3), in 1996.**

	May	Jul	Oct	Mean
Daphnia **Spp.**	<0.1	1.3	10.2	*3.8*
Leptodora kindtii	*0.0*	**3.7**	**1.9**	**1.9**
Total Cladocera	<0.1	5.0	12.1	**5.7**

Table 3.17 **Monthly and yearly mean zooplankton biomass values in mg/m^3 at Porcupine Bay (Index Station 4), in 1996.**

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Daphnia **Spp.**	0.0	<0.1	<0.1	0.8	136.0	80.6	11.7	182.6	7.5	119.1	53.8
L. kindtii	0.0	0.0	0.0	<0.1	5.8	0.0	0.4	<0.1	0.0	0.0	0.6
Total Cladocera	0.0	<0.1	<0.1	0.9	141.9	80.6	12.0	182.6	7.5	119.1	54.5

Table 3.18 **Monthly and yearly mean zooplankton biomass values in mg/m³ at the confluence of the Spokane River with the main-stem Columbia (Index Station Confluence), in 1996.**

	Mar	Apr	Jun	Aug	Sep	Nov	Dec	Mean
Daphnia Spp.	0.0	<0.1	<0.1	20.6	33.1	36.4	33.9	17.7
L. kindtii	0.0	0.0	0.0	2.2	0.6	0.0	0.0	0.4
Total Cladocera	0.0	co.1	<0.1	22.7	33.7	36.4	33.9	18.1

Table 3.19 **Monthly and yearly mean zooplankton biomass values in mg/m³ at Seven Bays (Index Station 6), in 1996.**

	Mar	Apr	May	Jun	Jul	Aug	Sep	Nov	Dec	Mean
Daphnia Spp.	0.0	<0.1	<0.1	2.6	26.7	19.0	32.0	36.3	1.8	13.2
L. kindtii	0.0	0.0	<0.1	<0.1	7.2	1.0	0.0	0.0	0.0	0.9
Total Cladocera	0.0	<0.1	<0.1	2.6	33.9	20.0	32.0	36.3	1.8	14.1

Table 3.20 **Monthly and yearly mean zooplankton biomass values in mg/m³ at Keller (Index Station 7), in 1996.**

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Daphnia Spp.	0.0	<0.1	0.3	0.7	9.7	51.1	85.4	34.4	3.8	4.1	19.0
L. kindtii	0.0	0.0	0.1	co.1	0.3	0.9	0.3	0.0	0.0	0.0	0.2
Total Cladocera	0.0	<0.1	0.4	0.7	10.0	52.0	85.7	34.4	3.8	4.1	19.2

Table 3.21 **Monthly and yearly mean zooplankton biomass values in mg/m³ at San Poil (Index Station 8), in 1996.**

	May	Jul	Oct	Mean
Daphnia Spp.	2.3	119.4	207.6	109.8
Leptodora kindtii	0.2	6.1	0.0	2.1
Total Cladocera	2.5	125.5	207.6	111.9

Table 3.22 Monthly and yearly mean zooplankton biomass values in mg/m^3 at Spring Canyon (Index Station 9), in 1996.

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
***Daphnia* Spp.**	<0.1	<0.1	0.1	1.9	101.3	58.4	77.0	4.7	2.5	79.2	32.5
L. kindtii	0.0	0.0	0.1	0.1	1.9	1.0	2.4	0.0	0.0	0.0	0.6
Total Cladocera	<0.1	<0.1	0.2	2.0	103.2	59.4	‘79.4	4.7	2.5	79.2	33.1

Table 3.23 Monthly and yearly mean zooplankton biomass values in mg/m^3 at Rufus Woods (Index Station 10), in 1996.

	Mar	Apr	May	Jun	Aug	Sep	Nov	Dec	Mean
***Daphnia* Spp.**	<0.1	<0.1	<0.1	1.2	37.2	18.6	0.6	51.5	13.6
L. kindtii	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	**0.1**
Total Cladocera	<0.1	<0.1	<0.1	1.2	38.2	18.6	0.6	51.5	13.7

Table 3.24 **Yearly mean zooplankton lengths (mm) with standard deviations, for select Cladocera at ten locations in 1996.**

	1	2	3	4	Conf	6	7	8	9	10
D.g.mendotae	—±—	—±—	—±—	2.1 ±0.0	—±—	1.0±0.4	—±—	—±—	1.1±0.3	—±—
D. retrocurva	0.7 +0.2	0.8+0.3	0.8+0.2	1.1+0.5	1.1+0.4	1.0+0.4	1.0+0.4	1.3+0.4	1.1+0.5	1.5+0.3
D.pulex	0.9 ±0.3	0.9 ±0.4	1.0±0.4	1.4±0.6	1.4+0.5	1.1±0.4	1.1±0.4	1.3±0.5	1.2±0.5	1.3±0.5
L.kindtii	6.0±1.4	6.0±—	6.3±2.5	5.7±2.1	6.5±3.1	6.5+3.2	4.4 ±2.1	6.3±2.5	3.8±1.8	7.8±3.3
Daphnia **Ave**	**0.8±0.3**	**0.9±0.4**	**0.9±0.4**	**1.3±0.6**	**1.3±0.5**	**1.1±0.4**	**1.1 ±0.4**	**1.3±0.5**	**1.2±0.5**	**1.3±0.5**

'—' Indicates no data or no organisms found.

3.24). Mean lengths at Spring Canyon were: *Daphnia galeata mendotae* - 1.1 mm; *Daphnia retrocurva - 1.1 mm; Daphnia pulex* - 1.2 *mm;* and *Leptodora kindtii - 4.1 mm* (Table 3.24). Mean lengths at Rufus Woods were: *Daphnia pulex* - 1.2 mm; and *Leptodora kindtii* - 3.0 mm (Table 3.24). Due to an error in zooplankton length calculations for 1995, the corrected data with corresponding changes in biomass values, have been re-submitted as part of Appendix B.

3.3 Rainbow Trout Tagging

In 1996, a total of 14,948 fish were tagged at the Kettle Falls and Seven Bays net-pens in April (Table 3.25). Of these fish, 4,998 were tagged at Kettle Falls and released in April and 9,950 were tagged at Seven Bays and released in June. A total of 228 tags were returned from anglers fishing in Lake Roosevelt or below in 1996, yielding an overall recapture rate of 1.5% (Table 3.25). Twenty six tags were returned from fish tagged at Kettle Falls, while 202 tags were returned from fish tagged at Seven Bays. The highest number of tag returns from the Kettle Falls releases came from the Rocky Reach Fish Passage Center (50%, n=13), followed by the McNary Dam Fish Passage Center (3 1%, n=8; Table 3.26). The highest number of returns from the Seven Bays tag releases came from the Keller Ferry area (27%, n=5 l), followed by the Seven Bays area (2 1 %, n=40) and the San Poil River area (14%, n=27; Table 3.27). Examination of release times versus water retention time and subsequent recapture rates indicates that entrainment rates for rainbow trout in 1996 were high, especially for fish released from the Kettle Falls area (Table 3.25). April releases from Kettle Falls resulted in 23 of 26 tag returns coming from below Lake Roosevelt, yielding a 89% estimated entrainment rate (Tables 3.25 and 3.26). In contrast, examination of tag return data for fish released in June indicates moderate entrainment, with 33 of 202 (16%) fish recaptured below Grand Coulee Darn (Table 3.25 and 3.27).

3.4 Creel Stirveys

We estimated that total annual fishing pressure exerted in Lake Roosevelt during 1996 was 744,861 angler hours (Table 3.28). Our estimates of annual fishing pressure were highest in Section 2 (38 1,232 hrs), moderate in Section 3 (277,598 hours), and lowest in Section 1 (86,032 hrs; Table 3.28). Monthly fishing pressure was greatest during July (343,011 hrs) and January (80,125 hrs), and lowest during November (5,121 hrs) and April (11,825 hrs; Table 3.28).

Table 3.25 **Summary of rainbow trout release times, water retention times and subsequent recapture numbers and percentages by year.**

							Recoveries Below Grand Coulee		
Release Date	Water Retention Time	Total # Tagged	Total # Recovered	Percent Recovered	Number Recovered in FDR	Percent Recovered in FDR	# Recovered in Rufus Woods	# Recovered at Rock Is. or McNary	% Recovered Below FDR
Mar. 89	36	768	8	1%	3	38%	0	5	63%
Mar. 90	32	1,441	7	0%	4	57%	0	3	43%
Mar. 92	48	5,999	107	2%	105	98%	2	0	2%
Mar. 93	67	7,974	15	<1%	14	93%	1	0	0%
Mar. 94	55	9,994	115	1%	113	98%	2	0	2%
Apr. 89	33	985	20	2%	11	55%	3	6	45%
Apr. 90	31	1,470	52	4%	38	73%	10	4	27%
Apr. 91	18	2,300	78	3%	52	67%	13	13	33%
Apr. 92	51	5,998	208	3%	204	98%	4	0	2%
Apr. 93	87	7,992	48	1%	48	100%	0	0	0%
Apr. 94	55	7,998	123	2%	121	98%	2	0	2%
Apr. 96	19	4,998	26	<1%	3	11%	0	23	89%
May 88	40	1,171	99	9%	99	100%	0	0	0%
May 90	29	1,450	54	4%	44	81%	8	2	19%
May 92	34	6,000	295	5%	283	96%	12	0	1%
May 93	39	4,999	66	1%	64	97%	2	0	0%
May 94	44	8,983	159	2%	155	98%	2	0	1%
May 95	47	12,984	200	2%	195	98%	4	1	3%
Jun. 91	29	296	32	11%	27	99%	5	0	1%
Jun. 92	34	3,000	139	5%	139	100%	0	0	0%
Jun. 93	50	296	11	4%	11	100%	0	0	0%
Jun. 96	16	9,950	202	2%	169	84%	16	17	16%
Jul. 91	62	1,749	155	9%	148	97%	7	0	3%

Table 3.26 Number and percent of tagged rainbow trout captured at various locations from the Kettle Falls releases in 1996.

CAPTURE LOCATION	# CAPTURED	% CAPTURED BY LOCATION
Kettle Falls	1	3.8
Keller Ferry	1	3.8
San Poil River	1	3.8
Rocky Reach Dam	13	50.0
McNary Dam	8	31.0
Wanapum Dam	1	3.8
Bonneville Dam	1	3.8
TOTAL	26	**100.0**

Table 3.27 Number and percent of tagged rainbow trout captured at various locations from the Seven Bays releases in 1996.

CAPTURE LOCATION	# CAPTURED	% CAPTURED
Porcupine Bay	17	8.9’
Seven Bays	40	20.8
Keller Ferry	51	26.6
San Poil	27	14.1
Spring Canyon	24	12.5
Rufus Woods	16	8.3
McNary Dam	16	8.3
Mouth of the Columbia	1	0.5
TOTAL	**192**	**100.0**

Table 3.28 Total monthly angler pressure estimates in hours (± 95% CI), by creel section on Lake Roosevelt from December, 1995 through November, 1996.

Month	Section 1	Section 2	Section 3	Total
December	1,241 ± 275	7,474 ± 421	4,480 ± 533	13,195 ± 1,229
January	501 ± 187	75,387 ± 3,505	4,237 ± 396	80,125 ± 4,088
February	503 ± 226	22,170 ± 1,671	3,723 ± 1,797	26,396 ± 3,694
March	822 ± 176	6,932 ± 710	14,647 ± 929	22,401 ± 1,815
April	941 ± 147	3,482 ± 163	7,402 ± 583	11,825 ± 893
May	5,094 ± 460	2,003 ± 155	60,103 ± 617	67,200 ± 1,232
June	21,241 ± 1,258	17,366 ± 489	12,929 ± 466	51,536 ± 2,213
July	45,175 ± 2,066	177,346 ± 7,614	120,490 ± 3,587	343,011 ± 13,267
August	4,585 ± 506	20,176-k 1,453	15,189 ± 158	39,950 ± 2,117
September	3,977 ± 178	29,536 ± 1,346	23,260 ± 953	56,773 ± 2,477
October	1,153 ± 0	15,814 ± 1,065	10,361 ± 498	27,328 ± 1,563
November	798 ± 94	3,546 ± 147	777 ± 51	5,121 ± 292
Total	86,032 ± 5,574	381,232 ± 18,739	277,598 ± 10,568	744,861 ± 34,880

Our estimates (from mean trip lengths and pressure estimates) indicate that anglers made 176,763 fishing trips to Lake Roosevelt from December, 1995 through November, 1996 (Table 3.29). An estimated total of 14,621 angler trips were made in Section 1, 118,285 angler trips in Section 2 and 43,857 trips in Section 3 during 1996 (Table 3.29). On a reservoir wide basis, the greatest number of estimated trips was during July (70,246). In all other months we estimated less than 20,000 angler trips were made to Lake Roosevelt.

As expected, fishing pressure and number of trips followed similar trends between months and sections in 1996. Both estimated pressure and estimated number of angler trips were generally high during late winter (January, February) and early spring through early fall (May -September), and relatively low during spring (March, April) and late fall / early winter (November - December; Tables 3.28 and 3.29).

During 1996, the overall mean annual harvest rate (fish kept per angler hour) in Lake Roosevelt for all species combined was 0.275, equating to 3.6 angler hours exerted for each fish harvested (Table 3.30). The 1996 annual mean harvest rate was 0.101 (9.9 angler hrs/fish) for rainbow trout, 0.163 (6.1 angler hrs/fish) for walleye, <0.001 (1,189 angler hrs/fish) for smallmouth bass *(Micropterus dolomieui),* and 0.007 (143 angler hrs/fish) for kokanee salmon (Table 3.30). The highest harvest rates by species were in Section 1 for walleye (0.331; 3.0 angler hrs/fish) and smallmouth bass (0.002; 500 angler hrs/fish), and in Section 3 for kokanee salmon (0.020; 50 angler hrs/fish) and rainbow trout (0.278; 3.6 angler hrs/fish; Table 3.30).

The overall mean annual catch rate (fish kept and released per angler hour) for all species combined in Lake Roosevelt during 1996 was 0.465, meaning that anglers exerted approximately 2.1 hours of effort for each fish caught (Table 3.3 1). Mean annual catch rates by species in 1996 were 0.103 (9.7 angler hrs/fish) for rainbow trout, 0.297 (3.31 angler hrs/fish) for walleye, 0.055 (18.2 angler hrs/fish) for smallmouth bass, and 0.007 (143 angler hrs/fish) for kokanee salmon (Table 3.31). Catch rates for individual species were highest in Section 1 for walleye (0.805; 1.2 angler hrs/fish) and in Section 3 for smallmouth bass (0.158; 6.3 angler hrs/fish), kokanee salmon (0.020; 50 angler hrs/fish) and rainbow trout (0.280; 3.6 angler hrs/fish; Table 3.3 1).

The largest contributors to harvest from the Lake Roosevelt fishery in 1996 were rainbow trout and walleye. Harvest of rainbow trout and walleye was estimated at 76,782 and 104,055 fish, respectively, accounting for over 99 percent of the total harvest (Table 3.32). Walleye were primarily harvested from Sections 1 (34,196) and 2 (67,942) whereas the

Table 3.29 **Angler trip estimates by section based on angler hours and average trip length for Lake Roosevelt from December, 1995 through November, 1996.**

	Section	Mean Trip Length	No. Angler Hours	No. Angler Trips
December	1	1.2	1,241	1,034
	2	2.8	7,474	2,669
	3	4.6	4,480	974
January	1	2.8	501	179
	2	4.3	75,387	17,532
	3	4.5	4,237	942
February	1	2.1	503	240
	2	1.8	22,170	12,317
	3	6.0	33,723	5,621
March	1	4.1	822	200
	2	4.3	6,932	1,612
	3	6.4	14,647	2,289
April	1	4.8	941	196
	2	4.3	3,482	810
	3	3.4	7,402	2,177
May	1	3.9	5,094	1,306
	2	4.3	2,003	466
	3	6.4	60,103	9,391
June	1	6.5	21,241	3,268
	2	4.3	17,366	4,039
	3	6.8	12,929	1,901
July	1	7.3	45,175	6,188
	2	3.5	177,346	50,670
	3	9.0	120,490	13,388
August	1	6.3	4,585	728
	2	1.3	20,176	15,520
	3	6.1	15,189	2,490
September	1	5.9	3,977	674
	2	4.5	29,536	6,564
	3	8.4	23,260	2,769
October	1	3.7	1,153	312
	2	3.2	15,814	4,942
	3	6.1	10,361	1,699
November	1	2.7	798	296
	2	3.1	3,546	1,144
	3	3.6	777	216
Total		5.38	744,861	176,763

Table 3.30 **Harvest per unit effort (HPUE) by species and section from December, 1995 through November, 1996 at Lake Roosevelt. HPUE equals the number of fish kept per angler hour.**

	Section			
	1	**2**	**3**	**Annual**
kokanee salmon	0.000	0.000	0.020	0.007
rainbow trout	0.011	0.011	0.278	0.101
walleye	0.331	0.042	0.004	0.163
smallmouth bass	0.002	0.000	0.000	<0.001
white sturgeon	0.000	0.000	0.000	0.000
other species	0.007	0.000	0.000	0.003
Annual HPUE	**0.351**	**0.054**	**0.302**	**0.275**

Table 3.31 **Catch per unit effort (CPUE) by species and section from December, 1995 through November, 1996 at Lake Roosevelt. CPUE equals the number of fish caught (kept or released) per angler hour.**

	Section			
	1	**2**	**3**	**Annual**
kokanee salmon	0.000	0.000	0.020	0.007
rainbow trout	0.012	0.011	0.280	0.103
walleye	**0.805**	**0.045**	**0.008**	**0.297**
smallmouth bass	0.002	0.003	0.158	0.055
white sturgeon	0.000	0.000	0.000	0.000
other species	0.012	0.000	0.000	0.004
Annual CPUE	**0.638**	**0.059**	**0.467**	**0.465**

Table 3.32 Estimated number of fish harvested (kept), with ± 95% confidence intervals, for Lake Roosevelt from December, 1995 through November, 1996.

	Section			
	1	2	3	Total
kokanee salmon	0	0	1,265 (±102)	**1,265 (±102)**
rainbow trout	1,714 (±111)	**4,628** (±345)	**70,440** (±3,216)	**76,782 (±3,672)**
walleye	34,196 (±1,914)	67,942 (±2,908)	1,917 (±68)	**104,055 (±4,890)**
smallmouth bass	**79** (±6)	0	0	**79 (±6)**
white sturgeon *	0	0	0	0
other species	301 (±21)	0	0	**301 (±21)**
Annual Harvest	**36,290 (±2,052)**	**72,569 (±3,253)**	**73,622 (±3,386)**	**182,482 (±8,691)**

* White sturgeon fishery was closed to harvest in 1996.

majority of rainbow trout were harvested from Section 3 (70,440; Table 3.32). Estimated harvest of kokanee salmon (1,265), smallmouth bass (79), and other species (301) accounted for less than one percent of the total harvest in 1996 (Table 3.32). Approximately 1.4 percent of the walleye observed in the creel during 1996 were within the illegal size restrictions (406 - 508 mm; 16 - 20 in.) established by WDFW. We estimated that 1,5 11 walleye were inadvertently harvested within the illegal size range in 1996. The white sturgeon *(Acipenser transmontanus)* fishery in Lake Roosevelt was limited to catch and release in 1996 which resulted in a harvest estimate of zero fish (Table 3.32).

Both catch rates and (estimated) numbers of fish caught from Lake Roosevelt during 1996 were similar to harvest rates / estimates for each species with the exception of walleye and smallmouth bass (Tables 3.30 through 3.33). The mean annual catch rates for walleye (0.297) and smallmouth bass (0.055) were considerably higher than mean annual harvest rates (0.0.163 and <0.001, respectively) in 1996 (Tables 3.30 and 3.31). Catch estimates for both walleye (142,873) and smallmouth bass (11,471) were also notably higher than harvest estimates for these species (104,055 and 79, respectively) in 1996 (Tables 3.32 and 3.33). Mean catch and harvest rates for 1996 followed similar trends between sections, and were relatively high in Sections 1 and 3, and relatively low in Section 2 (Tables 3.30 and 3.3 1). Estimated numbers of fish caught (Table 3.32) and harvested (Table 3.33) in 1996 were highest in Sections 2 and 3, and lowest in Section 1. Appendix A reports estimated 1996 catch and harvest by section, month and species.

In 1996, rainbow trout harvested from Section 2 were apparently larger by both length and weight than those harvested in Sections 1 or 3, although our sample size in Section 2 was low (Table 3.34). Mean length and weight of rainbow trout harvested from Sections 1 and 3 were similar in 1996 (Table 3.34). Rainbow trout harvested in Section 2 averaged 422 mm in length and 938 grams in weight (Table 3.34). In contrast, rainbow trout harvested from Sections 1 and 3 had respective mean lengths of 387 and 361 mm, and respective mean weights of 692 and 676 grams (Table 3.34).

Walleye observed in the creel in Section 1 during 1996 were smaller by length and weight than those observed in Sections 2 and 3 (Table 3.34). Walleye sampled in Section 1 had a mean length of 368 mm and a mean weight of 377 grams whereas walleye sampled from Sections 2 and 3 were similar in size, having mean lengths near 425 mm and mean weights over 690 grams (Table 3.34). Only 4 percent of walleye creeled in Section 1 during 1996

Table 3.33 Estimated number of fiih caught (kept and released), with ± 95% confidence intervals, for Lake Roosevelt from December, 1995 through November, 1996.

	Section			
	1	**2**	**3**	**Total**
kokanee salmon	0	0	1,265 (±102)	**1,265 (±102)**
rainbow trout	1,743 (±113)	4,628 (±345)	70,543 (±3,219)	76,914 (23,677)
walleye	68,031 (±3,679)	72,753 (±3,115)	2,089 (±74)	142,873 **(±6,868)**
smallmouth bass	**79** (±6)	4,811 (±207)	6,581 (±237)	**11,471 (±480)**
white sturgeon	0	0	0	0
other species	619 (±44)	0	0	**619 (±44)**
Annual Catch	70,474 **(±3,841)**	82,192 **(±3,667)**	80,478 **(±3,632)**	233,144 **(±11,140)**

Table 3.34 Annual numbers (n) and mean lengths (mm) and weights (g) for fish observed in the Lake Roosevelt creel from December, 1995 through November, 1996. Plus/minus values indicate standard deviations.

	Kokanee salmon	Rainbow	Walleye	Small-mouth Bass	Burbot	Yellow Perch
Ln	-	387+5618	368+50	30246	505s 19	9 281k25
Wt	-	6922213	3773t236	503~212	1117:1058	
Sec 2						
		8	30			
Ln	-	422+56	421~~65	-		
Wt	-	9382369	691ii281	-		
Sec 3						
Ln	438k424	361+5384	42821364	-		
Wt	**890&63**	676k3 15	11-872	-		
Total						
Ln	**43::42**	363zt5690	372+5537	3053,46	505:119	281+259
W t	**89O-c263**	**682&315**	**398*263**	**503&212**	**1117*1058**	**259:76**

were within the upper legal size limit (> 20 in). In contrast, 25 and 50 percent of the walleye creeled in Sections 2 and 3, respectively, were in the upper legal size limit.

Relative abundance of fishes other than rainbow trout and walleye in 1996 creel surveys was low and accounted for only 4 percent of the total number of fish observed (Table 3.34). Smallmouth bass, burbot, and yellow perch were noted in the creel exclusively from Section 1 during 1996 (Table 3.34). In contrast, kokanee salmon were noted in the creel only in Section 3 (Table 3.34).

Based on 1996 creel surveys, 80 percent of white sturgeon anglers and 64 percent of. walleye anglers were satisfied with the fishery in 1996 (Table 3.35). Satisfaction rates of anglers targeting rainbow trout (33%) or kokanee salmon (19%) were notably lower during the same period (Table 3.35). The highest satisfaction rates among rainbow trout and walleye anglers were during the summer months (June-August) in all sections and ranged. from 39 to 100 percent of anglers being satisfied (Table 3.35). Kokanee salmon anglers were only encountered in Section 3 in 1996, and were most satisfied in the spring (31%) and winter (21%) months (Table 3.35). White sturgeon anglers were only recorded in Section 1, and expressed 100% satisfaction during the summer and 0% satisfaction during the fall (Table 3.35).

Of all anglers interviewed on Lake Roosevelt during 1996, 44% targeted walleye, 26% targeted rainbow trout, 20% targeted kokanee salmon and 10% targeted other species (Table 3.36). On a reservoir wide basis, walleye were the principal species targeted in the spring (43%) and summer (63%) months, whereas kokanee salmon and rainbow trout were the principal target species during winter (48%) and fall (48%), respectively (Table 3.36). In Section 1, walleye were the most frequently targeted species during the spring (80%) and summer (96%), however rainbow trout were most frequently targeted in winter (96%) and fall (58%; Table 3.36). Section 2 was dominated by rainbow trout anglers during the winter (80%), spring (64%), and fall (48%), and by walleye anglers during summer (52%; Table 3.36). The fishery in Section 3 was dominated (55-100%) by kokanee salmon anglers in all seasons during 1996 (Table 3.36).

Table 3.37 shows the economic value of the sport fishery in Lake Roosevelt during 1996. Based on an estimated 195,628 angler trips at $39.00 per trip, the economic value of the Lake Roosevelt fishery in 1996 was $7,629,492.

3.5 Fisheries Surveys and Relative Abundance

Based on 1996 electrofishing and gillnet efforts, the most- common fish species in Lake Roosevelt was the largescale sucker *(Catostomus macrocheilus)* which made up 39 percent of our total catch (Table 3.38). Walleye were the second most abundant fish collected, comprising 19 percent of our total catch. Lake whitefish and rainbow trout each accounted for 7 percent of the total catch with smallmouth bass (6%), burbot (4%), and kokanee salmon (4%) also moderately abundant in our relative abundance surveys during 1996.

Electrofishing surveys were dominated by largescale suckers whereas lake whitefish were the most abundant species in gillnet surveys (Table 3.39). Walleye, burbot, and rainbow trout were relatively abundant in both electrofishing and gillnet surveys (Table 3.39). Smallmouth bass and kokanee salmon were also commonly collected by electrofishing during 1996 (Table 3.39).

In 1996 we sampled a total of 27 hours by electrofishing and 201.2 hours by gillnetting in Lake Roosevelt. A total of 3,092 fish were collected by electrofishing (2,734) and gillnet (358) surveys yielding an overall CPUE of 13.51 fish/hour. The total CPUE for electrofishing and gillnet surveys was 99.04 and 1.78 fish/hour, respectively, in 1996. Appendix B lists the number of fish captured, relative abundance, and CPUE by site, month and species for electrofishing and gillnet surveys conducted in 1996.

3.6 Age, Back Calculations and Condition Factor

Length, weight and scales were taken from each of 29 kokanee salmon collected during electrofishing and gillnet surveys in 1996. The mean condition factor of kokanee salmon was greater than 1 .00 for all ages, and ranged from 1.06 (age 3) to 1.54 (age 1; Table 3.40). Back calculated length at age of kokanee salmon indicated an average growth of 1 1 mm for the first year of life, 121 mm for the second year and 154 mm for the third year (Table 3.41). Back calculated growth increments for kokanee salmon translate to mean total lengths of 113 mm at age 1,234 mm at age 2, and 388 mm at age three (Table 3.41) Based on our data, kokanee salmon in the 1994 cohort were smaller than those in the 1993 cohort at both age 1 and 2 (Table 3.40 and 3.41). The 1995 kokanee salmon cohort (129 mm) was comparable in length to the 1993 cohort (128 mm) at age 1 (Table 3.41).

Table 3.35 Percent of anglers that were satisfied with the fishery by species, section and season from December, 1995 through November, 1996.

Quarter Section	Kokanee Salmon	Rainbow Trout	Walleye	White Sturgeon
Winter				
1		13%		
2	-	7%	0%	
3	21%			
Spring				
1			45%	
2		11%	0%	
3	31%			
Summer				
1		100%	80%	100%
2			39%	
3	12%	77%		
Fail				
1		16%	27%	0%
2		13%	0 %	
3	0%	82%		
Qrtly Totals				
Winter	21%	11%	0%	-
Spring	31%	12%	38%	-
Summer	12%	79%	77%	100%
Fall	0%	31%	13%	0%
Annual Total	19%	33%	64%	80%

Table 3.36 Percent of anglers targeting various fish species by section and season on Lake Roosevelt from December, 1995 through November, 1996.

Quarter Section	Kokanee Salmon	Rainbow	Walleye	Other*
Winter				
1	0%	96%	0%	4%
2	0%	80%	15%	5%
3	98%	0%	0%	2%
Spring				
1	0%	20%	80%	0%
2	0%	64%	36%	0%
3	100%	0%	0%	0%
Summer				
1	0%	2%	96%	2%
2	4%	9%	52%	35%
3	63%	36%	0%	1%
Fall				
1	0%	58%	39%	3%
2	0%	48%	26%	26%
3	55%	38%	0%	7%
Qrtly Totals				
Winter	48%	44%	5%	3%
Spring	25%	32%	43%	0%
Summer	13%	11%	63%	13%
Fall	12%	48%	24%	16%
Annual Total	20%	26%	44%	10%

* Includes anglers targeting 'any' fish.

Table 3.37 Economic value of the sport fishery at Lake Roosevelt during December, 1995 through November, 1996.

	1985	1996
Consumer Price Index	$167.87	$25 1.80
Dollars Spent per Angler Trip	$26.00	$39.00
Number of Angler Trips		195,628
Economic Value of Fishery		**$7,629,492**

Table 3.38 Relative abundance of fish collected by electrofishing boat and gillnets in Lake Roosevelt during 1996.

Family species	Common Name	Electro-fishing	Gillnet	Annual
Catostomidae				
Catostomus macrocheilus	largescale sucker	46%	6%	39%
Catostomus catostomus	longnose sucker	1%	1%	1%
Catostomu columbianus	bridgelip sucker	2%	<l%	2%
Centrarchidae				
Microptenus dolomieui	smallmouth bass	7%	0%	6%
Cottidae				
Cottus beldingi	piute sculpin	1%	0%	<l%
Cyprinidae				
Cyprinus carpio	carp	2%	1%	2%
Ptychocheilus oregonensis	northern squawfish	2%	<l%	2%
Gadidae				
Lota lota	burbot	4%	10%	4%
Ictaluridae				
Ictalurus nebulosus	brown bullhead	0%	<l%	<1%
Percidae				
Stizostedion vitreum vitreum	walleye	20%	15%	19%
Perca flavescens	yellow perch	2%	3%	2%
Salmonidae				
Salmo trutta	brown trout	2%	0%	2%
Salvelinus fontinalis	brook trout	1%	0%	<l%
Oncorhynchus nerka	kokanee salmon	4%	5%	4%
Coregonus clupeafomis	lake whitefish	<l%	51%	7%
Prosopium williamsoni	mt. whitefish	<l%	0%	<1%
Oncorhynchus mykiss	rainbow trout	7%	6%	7%

Table 3.39 **Catch per unit effort based on time (hours) for fish captured by electrofishing boat or gillnets during 1996.**

	Electrofish		Gillnet		Total	
	CPUE	No.	CPUE	No.	CPUE	No.
brook trout	0.96	26	0.00	0	0.11	26
brown bullhead	0.00	0	<0.0l	1	<0.01	1
bridgelip sucker	2.22	60	<0.01	1	0.27	61
brown trout	2.15	58	0.00	0	0.25	58
burbot	3.55	96	0.18	36	0.58	132
carp	2.18	59	0.02	4	0.28	63
Cottus spp.	1.04	28	0.00	0	0.12	28
kokanee salmon	4.40	119	0.08	16	0.59	135
lake whitefish	0.59	16	0.91	184	0.87	200
largescale sucker	45.15	1,220	0.11	23	5.23	1,243
longnose sucker	1.33	36	0.02	5	0.16	41
mountain whitefish	0.07	2	0.00	0	0.01	2
northern squawfish	2.04	55	0.01	3	0.25	58
rainbow trout	6.92	187	0.11	22	0.91	209
smallmouth bass	6.62	179	0.00	0	0.78	179
tench	0.11	3	0.00	0	0.01	3
walleye	20.06	542	0.26	52	2.60	594
yellow perch	1.78	48	0.05	11	0.26	59
Totals	99.04	2,734	1.78	358	13.51	3,092

Table 3.40 Lengths, weights, and condition factors (mean ± standard deviation) of kokanee salmon collected during 1996.

Age	n	Length (mm)	Weight (g)	Condition Factor
0+	1	90 ± 0	10 ± 0	1.37 ± 0
l+	1	226 ± 0	178 ± 0	1.54 ± 0
2+	16	302 ± 26	401 ± 125	1.41 ± 0.17
3+	11	441 ± 59	916 ± 292	1.06 ± 0.13

Table 3.41 Back calculated total length (mean ± standard deviation) of kokanee salmon sampled during 1996.

		Back Calculated Total Length (mm) at Annulus		
Cohort	**n**	**1**	**2**	**3**
1995	1	129 ± 0		
1994	16	101 ± 23	215 ± 38	
1993	11	128 ± 29	262 ± 48	388 ± 48
Grand Mean	**28**	**113 ± 28**	234 ± 48	**388 ± 48**
Annual Growth		**113**	**121**	**154**

Lengths, weights and condition factors were determined for 84 rainbow trout collected during gillnet and electrofishing surveys in 1996 (Table 3.42). Condition factors of rainbow trout ranged from 0.87 (age 5) to 1.49 (age 0) and generally decreased with age (Table 3.42). Condition factors for ages 0 through 3 were similar and relatively high (> 1.40), whereas those of older cohorts were somewhat reduced (Table 3.42). Mean back calculated lengths at each age show a similar trend, with growth being consistently high during the first three years of life (110 - 113 mm/yr.), followed by a decline in older age classes (93 - 94 mm/yr.; Table 3.43).

Table 3.42 Lengths, weights, and condition factors (mean ± standard deviation) of rainbow. trout collected during 1996.

Age	n	Length (mm)	Weight (g)	Condition Factor
0+	2	171 ± 34	81 ± 52	1.49 ± 0.15
l+	13	194 ± 42	106 ± 67	1.42 ± 0.27
2+	6	314 ± 26	440 ± 178	1.41 ± 0.59
3+	50	389 ± 44	690 ± 230	1.14 ± 0.14
4+	12	463 ± 64	1,072 ± 354	1.15 ± 0.37
5+	1	535 ± 0	1,325 ± 0	0.87 ± 0.00

Table 3.43 Back calculated total length (mean ± standard deviation) of rainbow trout sampled during 1996.

		Back Calculated Total Length (mm) at Annulus				
Cohort	**n**	**1**	2	3	4	5
1995	13	106 ± 22				
1994	6	127 ± 19	244 ± 26			
1993	49	116 ± 29	224 ± 50	336 ± 52		
1992	12	105 ± 30	229 ± 57	334 ± 60	423 ± 61	
1991	1	75 ± 0	193 ± 0	355 ± 0	491 ± 0	523 ± 0
Grand Mean	**81**	**113 ± 28**	226 ± 49	336 ± 53	**430 ± 61**	**523** ± 0
Annual Growth		**113**	**113**	**110**	94	93

We determined length, weight and condition factor of 240 walleye sampled by electrofishing and gillnet surveys in 1996 (Table 3.44). Walleye collected in 1996 ranged from age 0 to age 7, and the mean condition factor for age 1 walleye (1.16) was slightly higher than those of walleye from age 2 through 7 (0.74 - 0.96; Table 3.44). Back calculated length at age shows relatively rapid growth (109 - 114 mm/yr.) in younger walleye (age 1 and 2), with a steady decline in growth rate thereafter (Table 3.45). Back calculated lengths for individual cohorts show a generally decreasing trend in growth rates over time which is most notable since 1992 (Table 3.45).

Table 3.44 Lengths, weights, and condition factors (mean = standard deviation) of walleye collected during 1996.

Age	n	Length (mm)	Weight (g)	Condition Factor
0+	0	-- ± --	-- ± --	-- ± --
1+	29	177 ± 28	70 ± 34	1.16 ± 0.32
2+	54	265 ± 52	183 ± 84	0.96 ± 0.39
3+	70	343 ± 41	348 ± 128	0.85 ± 0.26
4+	56	441 ± 39	801 ± 267	0.93 ± 0.19
5+	19	498 ± 53	1,214 ± 491	0.89 ± 0.13
6+	9	529 ± 44'	1,492 ± 341	0.95 ± 0.12
7+	3	596 ± 111	1,402 ± 829	0.74 ± 0.44

3.7 Feeding Habits

Stomach contents were examined from 15 kokanee salmon, 56 rainbow trout, and 126 walleye during 1996. Calculated IRI values indicated that cladocerans were the most important food item consumed by kokanee salmon (IRI = 87.83) and rainbow trout (IRI = 4 1.16; Table 3.46). Chironomidae, net pen food, terrestrial insects, and Corixidae were also important in the diet of rainbow trout and had respective IRI values of 20.74, 9.32, 7.22, and 4.10 (Table 3.46). Fish were the most important food item in walleye diets, and had a combined IRI equal to 77.16 (Table 3.46). Further breakdown of food items consumed by kokanee salmon, rainbow trout, and walleye can be found in Appendix C.

Based on data collected in 1996, diet overlap was greatest between kokanee salmon and rainbow trout (0.72). Walleye and rainbow trout exhibited intermediate dietary overlap (0.35), whereas walleye and kokanee salmon exhibited minimal dietary overlap (0.07).

Daphnia pulex was the only species of *Daphnia* identified from kokanee salmon and rainbow trout stomachs in 1996 (Table 3.46). Electivity index values show that both kokanee salmon and rainbow trout in Lake Roosevelt select against small (< 1.3 mm) *Daphnia* spp. in their diet (Tables 3.46 and 3.47). Kokanee salmon selectively consumed *Daphnia pulex* over 1.3 mm in 1996, and showed the highest selection (0.26) for those between 1.9 and 2.1 mm (Table 3.47). Rainbow trout selected for slightly larger zooplankton in the diet than kokanee salmon, and selectively consumed *Daphnia pulex* over 1.9 mm in 1996, showing the highest selection (0.23 to 0.24) for those between 2.2 and 2.7 mm (Table 3.48).

Table 3.45 Back calculated total length (mean ± standard deviation) of walleye sampled during 1996,

Cohort	n	Back Calculated Total Length (mm) at Annulus 1	2	3	4	5	6	7
1995	29	115 ± 31						
1994	54	110 ± 26	211 ± 43					
1993	70	105 ± 25	205 ± 43	296 ± 41				
1992	56	124 ± 25	244 ± 34	329 ± 42	399 ± 42			
1991	19	123 ± 30	234 ± 42	323 ± 52	394 ± 51	455 ± 52		
1990	9	120 ± 23	253 ± 37	336 ± 60	383 ± 59	441 ± 63	497 ± 51	
1989	3	136 ± 32	275 ± 18	378 ± 57	448 ± 75	507 ± 104	544 ± 119	576 ± 114
Grand Mean	240	114 ± 27	223 ± 44	315 ± 48	398 ± 48	458 ± 61	509 ± 70	587 ± 112
Annual Growth		114	109	92	83	60	51	78

Table 3.46 **Index of relative importance for kokanee salmon (n=15), rainbow trout (n=56), and walleye (n=126) from fish collected during 1996**

PREY ITEM	Index of Relative Importance Kokanee salmon	Rainbow	Walleye
Osteichthyes			
Catostomidae	--	--	3.25
Cottidae	--	--	11.68
Cyprinidae	--		1.94
Percidae	--	044	5.35
Salmonidae	--		28.31
Unidentified fish	--	1.33	26.63
Fish eggs	--	3.74	--
Amphipoda			
Gamma rus spp .	--	0.79	0.61
Cladocera			
D. pulex	30.88	26.31	--
L. kindtii	18.92	10.24	5.69
Daphnia spp.	27.52	4.61	--
B. longirostris	10.51	--	0.31
Eacopepoda			
Copepoda spp.	1.93	0.79	--
Basommatophora			
Physidae	--	0.39	--
Diptera			
Chironomidae pupa	8.30	9.15	3.71
Chironomidae larvae	--	4.03	6.50
Chironomidae adult	--	2.59	--
Simulidae pupa	--	0.46	--
Simulidae larvae	--	4.51	0.31
Trichoptera			
Limnephilidae	--	1.24	0.61
Hydropyschidae	--	0.79	0.36
Brachycentridae	--	--	0.31
Hemiptera			
Corixidae	--	4.10	0.31
Plecoptera			
Capniidae	--	0.39	
Nemouridae	--	--	0.31
Pteronarcydae	--	--	0.31
Ephemeroptera			
Baetidae	--	2.00	
Ephemerellidae	--	0.80	0.31
Heptageniidae	--	1.60	--
Leptophlebiidae	--	0.79	--
Odonata			
Zygoptera	--	--	1.84
Oligochaeta			
Lumbriculidae	--	1.97	0.31
Hydrachnellae			
Hydracharina	--	0.41	--
Terrestrial			
Insects	1.94	7.22	1.06
Net Pen Food	--	*9.32*	--

Table 3.47 **Electivity of kokanee salmon for different size classes of D. *pulex* in October, 1996 with relative proportions observed in stomach samples (r_i) and the environment (p_i).**

Daphnia pulex Size Range (mm)	Relative % In Stomach (r_i)	Relative % In Environment (p_i)	Electivity Index (L)
0.4 - 0.6	<0.1	31.0	- 0.31
0.7 - 0.9	2.0	31.0	- 0.29
1.0 -1.2	2.0	26.0	- 0.24
1.3 - 1.5	23.0	8.0	0.15
1.6 - 1.8	18.0	3.0	0.15
1.9 - 2.1	27.0	1.0	0.26
2.2 - 2.4	17.0	<0.1	0.17
2.5 - 2.7	9.0	<0.1	0.09
2.8 - 3.0	2.0	<0.1	0.02
Total	**100.0**	**100.0**	

Table 3.48 **Electivity of rainbow trout for different size classes of *D. pulex* in October, 1996 with relative proportions observed in stomach samples (r_i) and the environment (p_i).**

Daphnia pulex Size Range (mm)	Relative % In Stomach (r_i)	Relative % In Environment (p_i)	Electivity Index (L)
0.4 - 0.6	<0.1	8.0	- 0.08
0.7 - 0.9	<0.1	18.0	- 0.18
1.0 -1.2	1.0	35.0	- 0.34
1.3 - 1.5	3.0	23.0	- 0.20
1.6 - 1.8	9.0	9.0	0.00
1.9 - 2.1	23.0	4.0	0.19
2.2 - 2.4	27.0	3.0	0.24
2.5 - 2.7	23.0	<0.1	0.23
2.8 - 3.0	8.0	<0.1	0.08
3.1-3.3	4.0	<0.1	0.04
3.4-3.6	2.0	<0.1	0.02
Total	**100.0**	**100.0**	

4.0 DISCUSSION

4.1 Hydrology

4.1.1 Reservoir Operations

Grand Coulee Dam was commissioned by congress to operate for power, flood control, irrigation, recreation, and navigation. Reservoir operations therefore differ between years and seasons dependent on many factors. Reservoir operations during January and February, 1996 were predominantly controlled by power production needs and resulted in lake elevations being held fairly stable from January 1 through February 15 (Figure 3.1). Lake Roosevelt reservoir operations during March and April, 1996 were determined primarily by flood control needs due to high spring runoff (125 % of normal at Grand Coulee Dam from January through July), resulting in Lake Roosevelt being drawn down to its lowest level since 1991 (1,227 ft.; Figure 3.1). Reservoir operations during May and June, 1996 were directed at meeting refill objectives (85% probability of refill by July 1) as well as the flow targets at Priest Rapids and McNary Dams defined by the National Marine Fisheries Service's (NMFS) Biological Opinion. In 1996, Lake Roosevelt also released water to meet anadromous fish needs in accordance with the Endangered Species Act (ESA) and NMFS Biological Opinion resulting in a ten foot drawdown during August (Figure 3.1). From September through December, 1996 Lake Roosevelt was operated primarily for power production. Reservoir hydrology during 1996 was similar to that observed in 1991 in Lake Roosevelt (Figures 4.1 and 4.2).

Monthly lake elevations and storage volume differed substantially from 1994 through 1996 in Lake Roosevelt. Reservoir elevations in 1994 remained relatively stable due to a relatively dry year (91 % of normal at Grand Coulee Dam from January through July) which eliminated the need for extensive lower river flood control (Figure 4.3). Reservoir elevations for 1995, reflected a larger spring drawdown than occurred in 1994 (Figure 4.3) due to slightly above normal precipitation for the year (103 % of normal at Grand Coulee Dam from January through July). In comparison, the 1996 water year resulted in reservoir elevations being dropped to their lowest level since 199 1 (Figure 4.3) to buffer the lower river system from above average spring runoffs. Changes in precipitation and reservoir inflow rates also corresponded to changes in water retention times between years. Water retention times in Lake Roosevelt during 1994 and 1995 were higher than those observed in 1996 (Figure 4.2). This resulted from higher inflow and outflow volumes and from

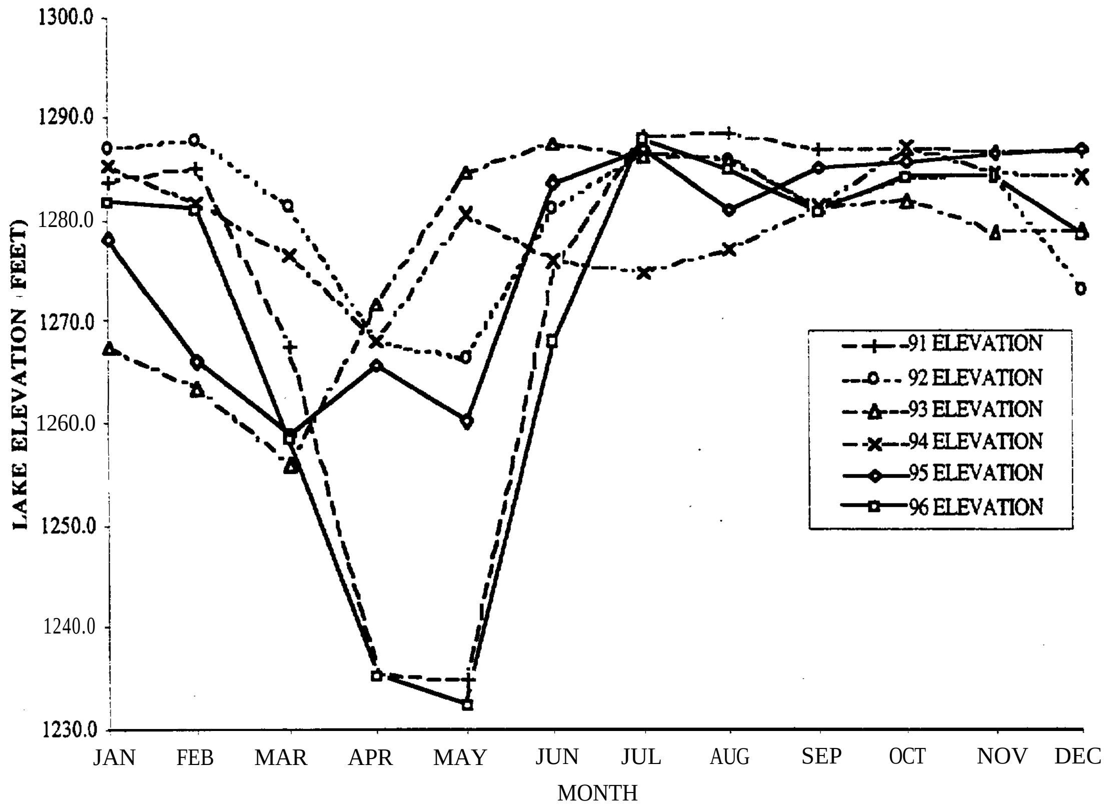


Figure 4.1 Mean monthly reservoir elevations from 1991 through 1996.

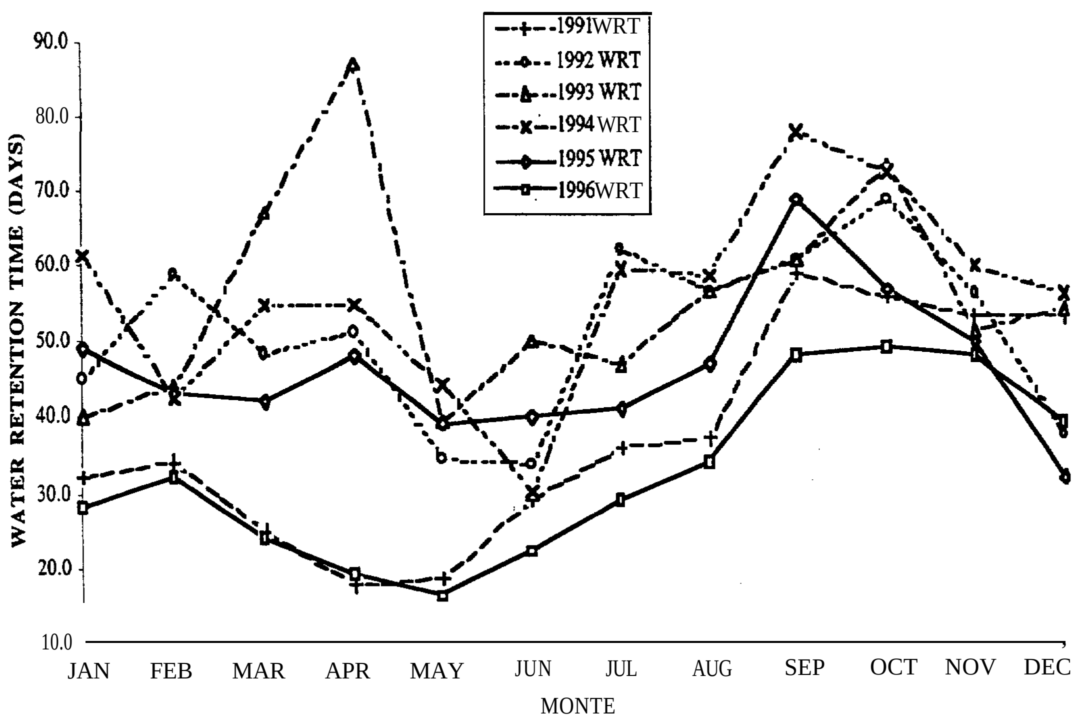


Figure 4.2 Mean monthly water retention times from 1991 through 1996.

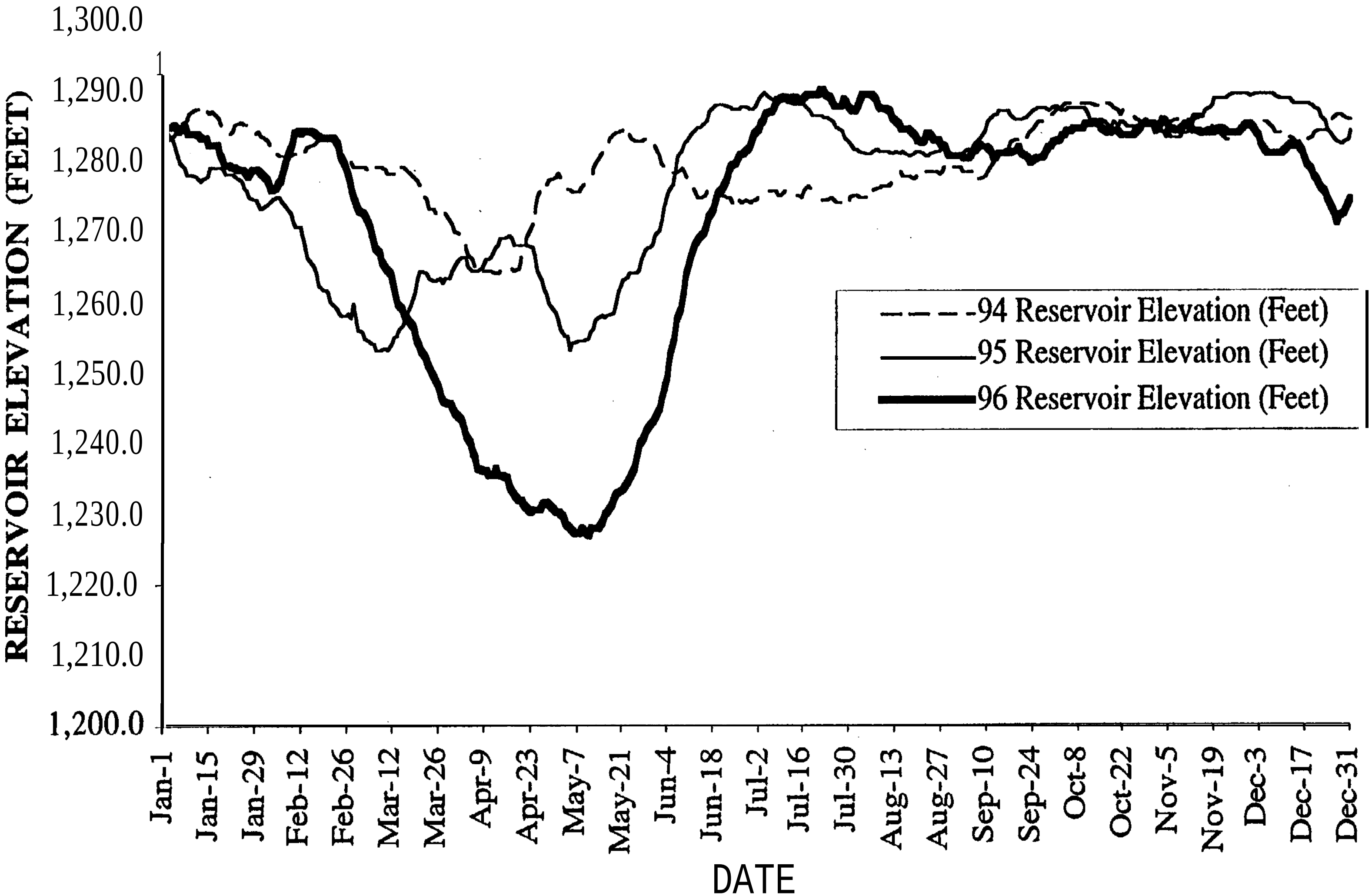


Figure 4.3 Comparison of 1994 through 1996 Lake Roosevelt elevations in feet.

corresponding flood control operations implemented in 1996. Mean yearly water retention times were 59.4 days in 1994, 46.5 days in 1995 and 32.3 days in 1996 (Table 4.1). Average reservoir elevation in 1996 was reduced by nearly 6 feet relative to 1995 and 8.5 feet relative to 1994. Outflow and inflow volumes were substantially increased in 1996 relative to 1994 and 1995 (Table 4.1). Yearly average reservoir storage volume was reduced from approximately 4,100 kcfsd in 1994 and 1995 to 3,90 1 kcfsd in 1996 as a result of the larger drawdown (Table 4.1).

4.1.2 Water Quality

Water temperatures were lowest in March for all sites in 1996, and highest from July through September, 1996 (Appendix C). A comparison of 1994 through 1996 mean 12 m water temperatures at five sites suggests that reservoir operations have the potential to impact reservoir water temperatures. Temperature data for May through October, 1996 indicate that 12m water temperatures averaged 1.6 °C lower than those observed over the same period in either 1994 or 1995 (Figure 4.4). Reduced temperatures in 1996 may be the result of changes in lake operations brought about by higher yearly precipitation, threats of downstream flooding and anadromous fish flows. However, temperature differences may also be related to variable climatic and runoff conditions between years. Secchi disk measurements were comparable in Lake Roosevelt from 1994 through 1996.

4.2 Impacts of Reservoir Operations on Zooplankton

As is consistent in most years, *Daphnia* spp. and total zooplankton densities remained low through either May or June at most sites during 1996. Starting in May, total zooplankton densities rapidly increased at all sites except Gifford and Porcupine Bay. This was followed by an increase in *Daphnia* spp. densities starting in June. Most sites showed a single peak in *Daphnia* spp. and total zooplankton densities over the summer, followed by a decline in abundance by November. Porcupine Bay was the only site exhibiting a double peak in *Daphnia* spp. and total zooplankton abundance in 1996 (Figures 4.5 and 4.6).

The impacts of reservoir operations on zooplankton populations are often difficult to measure because of the multitude of variables involved. Reservoir elevation, water retention time, water temperature, entrainment rate and many other factors can be influenced by operations at Grand Coulee Dam to varying degrees. Additional factors such as precipitation, nutrient levels and predation rates also play significant roles in determining zooplankton abundance. The dynamic nature of each of these variables complicates

Table 4.1 **Monthly and annual means for reservoir inflow, outflow, elevation, storage volume, and water retention time for Lake Roosevelt in 1994, 1995 and 1996.**

Month	Inflow (kcfs)	Outflow (kcfs)	Reservoir Elevation (Ft)	Storage Volume (kcfsd)	Water Retention Time (Days)
Jan. 1996	**148.5**	**154.9**	1,281.7	4,261.2	28.4
Jan. 1995	73.0	88.3	1,278.3	4,127.8	49.3
Jan. 1994	81.0	77.2	1,285.4	4,403.6	61.8
Feb. 1996	**167.3**	**154.9**	**1,280.9**	4,227.0	31.7
Feb. 1995	81.7	94.0	1,266.2	3,688.9	42.6
Feb. 1994	97.5	103.6	1,281.8	4,261.2	42.5
Mar. 1996	125.1	144.4	**1,258.5**	3,420.O	23.9
Mar. 1995	101.6	90.1	1,259.0	3,434.3	42.4
Mar. 1994	67.9	77.7	1,276.5	4,061.l	54.9
Apr. 1996	153.0	147.7	1,235.l	**2,679.l**	18.6
Apr. 1995	81.2	84.5	1,265.8	**3,669.5**	47.5
Apr. 1994	89.5	73.0	1,268.l	3,754.4	55.0
May 1996	**196.0**	167.8	1,232.3	2,597.9	15.7
May 1995	112.3	93.5	1,260.l	3,460.4	39.4
May 1994,	112.4	99.6	1,280.6	4,215.O	44.0
Jun. 1996	243.2	173.1	1,267.8	3,752.3	21.8
Jun. 1995	148.1	117.8	1,283.6	4,335.3	40.1
Jun. 1994	133.1	135.9	1,276.O	4,041.3	30.1
Jul. 1996	**174.4**	157.9	**1,287.9**	4,508.l	29.4
Jul. 1995	111.6	110.5	1,287.0	4,467.4	41.4
Jul. 1994	101.7	95.8	1,274.9	3,996.1	43.5
Aug. 1996	**130.2**	131.2	**1,284.9**	4,392.5	34.3
Aug. 1995	**96.3**	91.9	1,280.9	4,227.8	47.2
Aug. 1994	82.5	73.3	1,277.l	4,080.O	58.7
Sep. 1996	97.2	90.8	**1,280.7**	**4,219.2**	47.9
Sep. 1995	79.9	65.9	1,285.l	**4,392.8**	69.0
Sep. 1994	67.6	55.9	1,281.3	4,244.6	78.4
Oct. 1996	96.9	90.7	**1,284.l**	4,352.5	49.2
Oct. 1995	80.3	80.6	1,285.8	4,420.3	56.7
Oct. 1994	61.6	64.0	1,287.2	4,474.0	72.6
Nov. 1996	94.7	93.9	**1,284.2**	4,355.5	48.3
Nov. 1995	97.2	91.9	1,286.5	4,448.3	50.4
Nov. 1994	75.5	75.7	1,284.7	4,374.9	60.1
Dec. 1996	98.3	**110.7**	**1,278.5**	4,042.2	**38.9**
Dec. 1995	135.7	141.6	1,287.O	4,466.7	32.4
Dec. 1994	85.0	83.5	1,284.2	4,356.8	56.3
Annual 1996	**143.5**	**140.5**	1,271.4	3,907.8	31.7
Annual 1995	100.0	96.0	1,277.l	4,097.0	46.5
Annual 1994	87.8	84.4	1,279.8	4,189.0	54.9

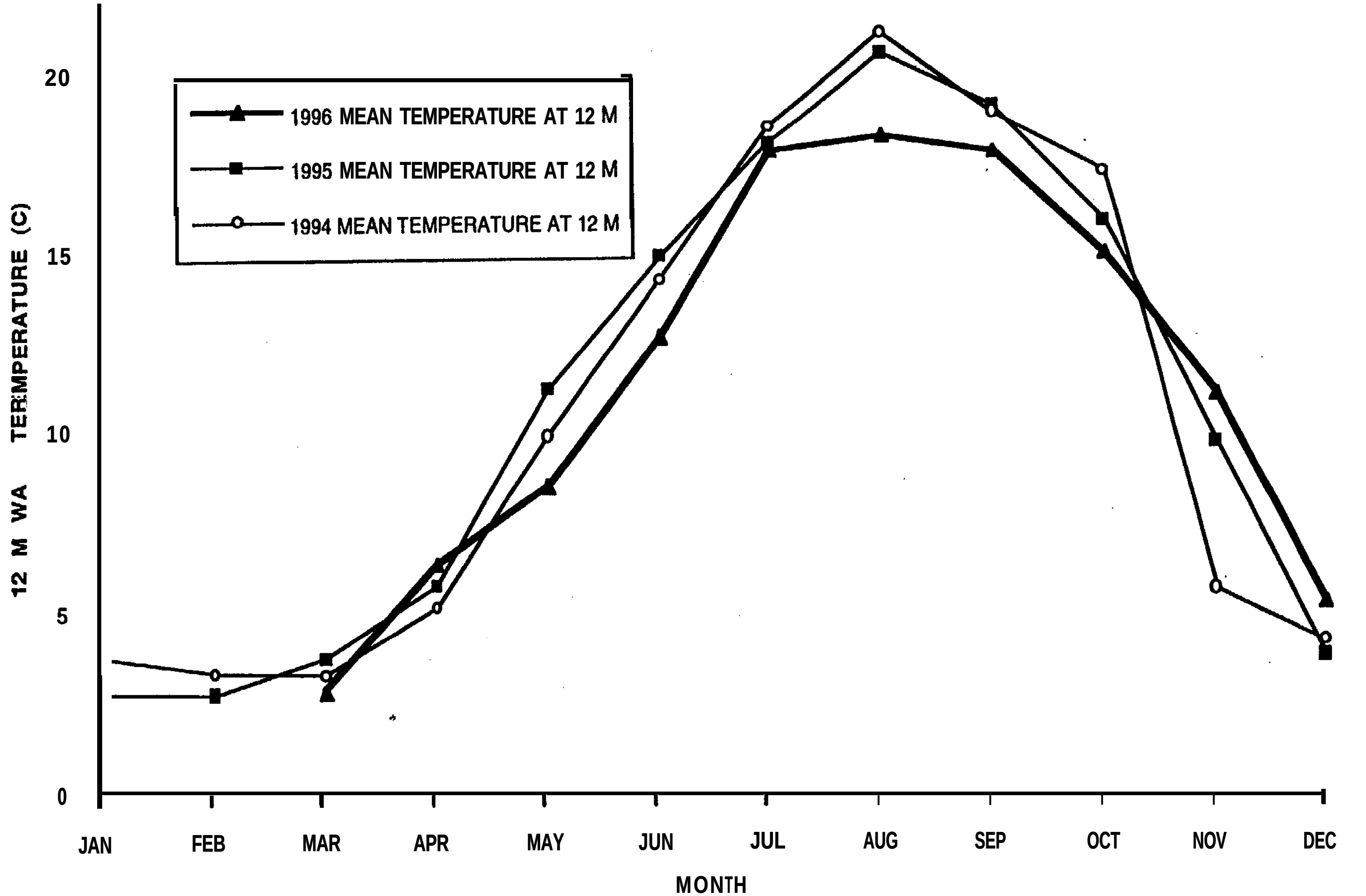


Figure 4.4 Plot of 12 meter water temperature versus month in Lake Roosevelt for the 1994, 1995 and 1996 sampling seasons.

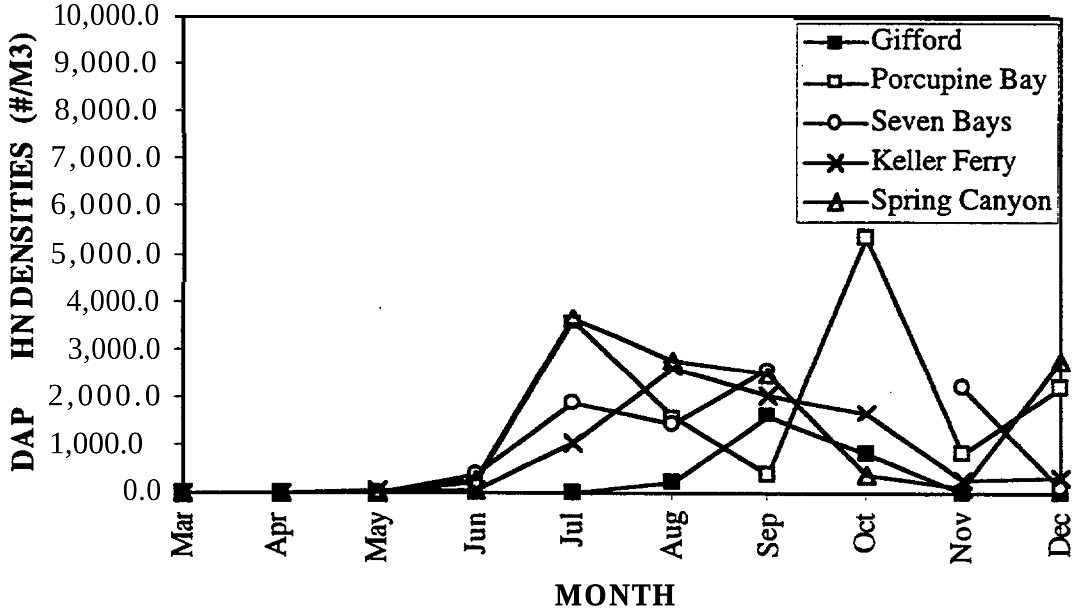


Figure 4.5 Mean *Daphnia* densities (#/m³) at Gifford, Porcupine Bay, Seven Bays, Keller Ferry and Spring Canyon in 1996.

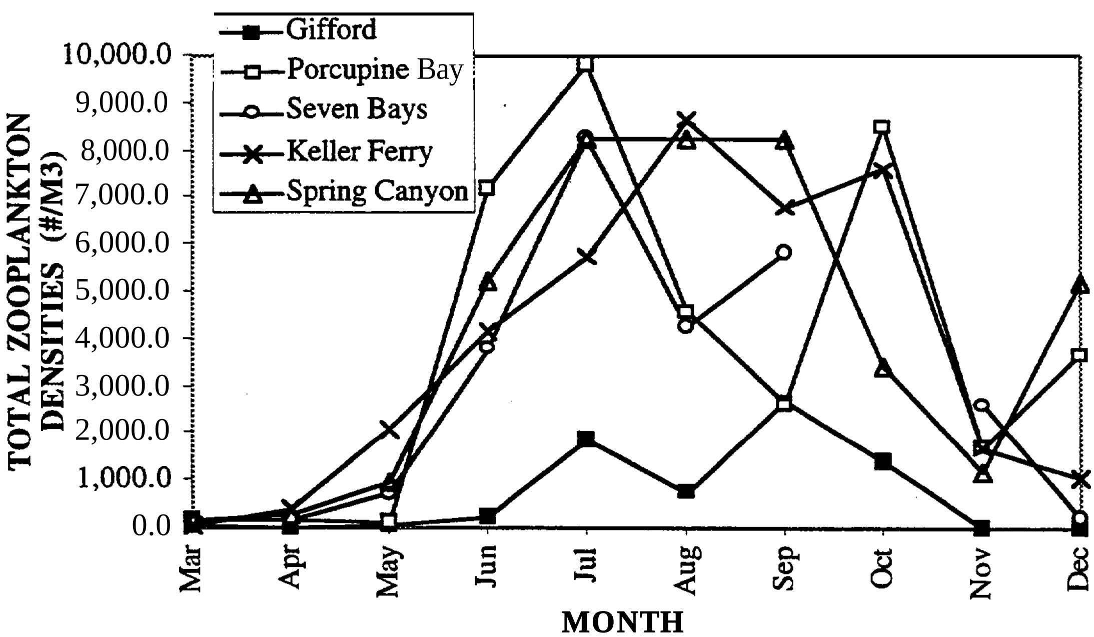


Figure 4.6 Mean total zooplankton densities (#/m³) at Gifford, Porcupine Bay, Seven Bays, Keller Ferry and Spring Canyon in 1996.

quantification of impacts from reservoir operations on lake biota. However, changes in the hydrology of Lake Roosevelt resulting from various operations have given us the opportunity to make between year comparisons and to investigate relationships between reservoir operations and zooplankton populations. Comparison of daily reservoir elevations for 1994 through 1996, indicates the degree of variation in water levels resulting from changes in reservoir operations (Figure 4.3). While the impact on zooplankton production resulting from lake operations is not fully understood, it appears that decreased reservoir elevations and water retention times impact zooplankton populations by inducing shifts in species composition or influencing production rates. Lake operations that result in decreased zooplankton production (especially *Daphnia* spp.) may also lead to reduced production in planktivores such as kokanee salmon.

It is well known that zooplankton densities and growth are dependent upon many factors, but perhaps the most important factor affecting zooplankton production is water temperature (Korpelainen 1986; Allan 1977; Hall 1964). As in previous years, our examination of zooplankton densities has indicated that water temperature may play a major role in population dynamics of zooplankton in Lake Roosevelt. Warm water temperatures (above 12 ^{0}C) correspond to dramatically increased densities of *Daphnia* spp. (Figure 4.7). Similar trends in temperature and *Daphnia* spp. can be seen for all years since 199 1. Therefore, any seasonal variations or changes in reservoir operations that reduce water temperature during the growing season may potentially reduce *Daphnia* spp. production. Temperature influences or is influenced by many other factors including climatic conditions, nutrient availability, phytoplankton production, and zooplankton feeding, growth, and production rates. The complex interaction of temperatures with other factors makes the direct influence of temperature on *Daphnia* spp. density unclear. However, temperature does appear to be an accurate indicator of trends in *Daphnia* spp. abundance and therefore may be used interpret the effects of other factors which influence water temperatures (i.e. reservoir operations).

Differential temperature tolerance exists among cladocerans (LaBerge and Hann 1990; Goss and Bunting 1983) and may cause changes in the species composition of phytoplankton and zooplankton communities with variations in water temperatures (Johannsson and O'Gormann 199 1). From 1994 through 1996, higher mean 12 m temperatures during the summer months corresponded with the highest *Daphnia* spp. densities (Figures 4.4 and 4.8). However, the same comparison using total zooplankton

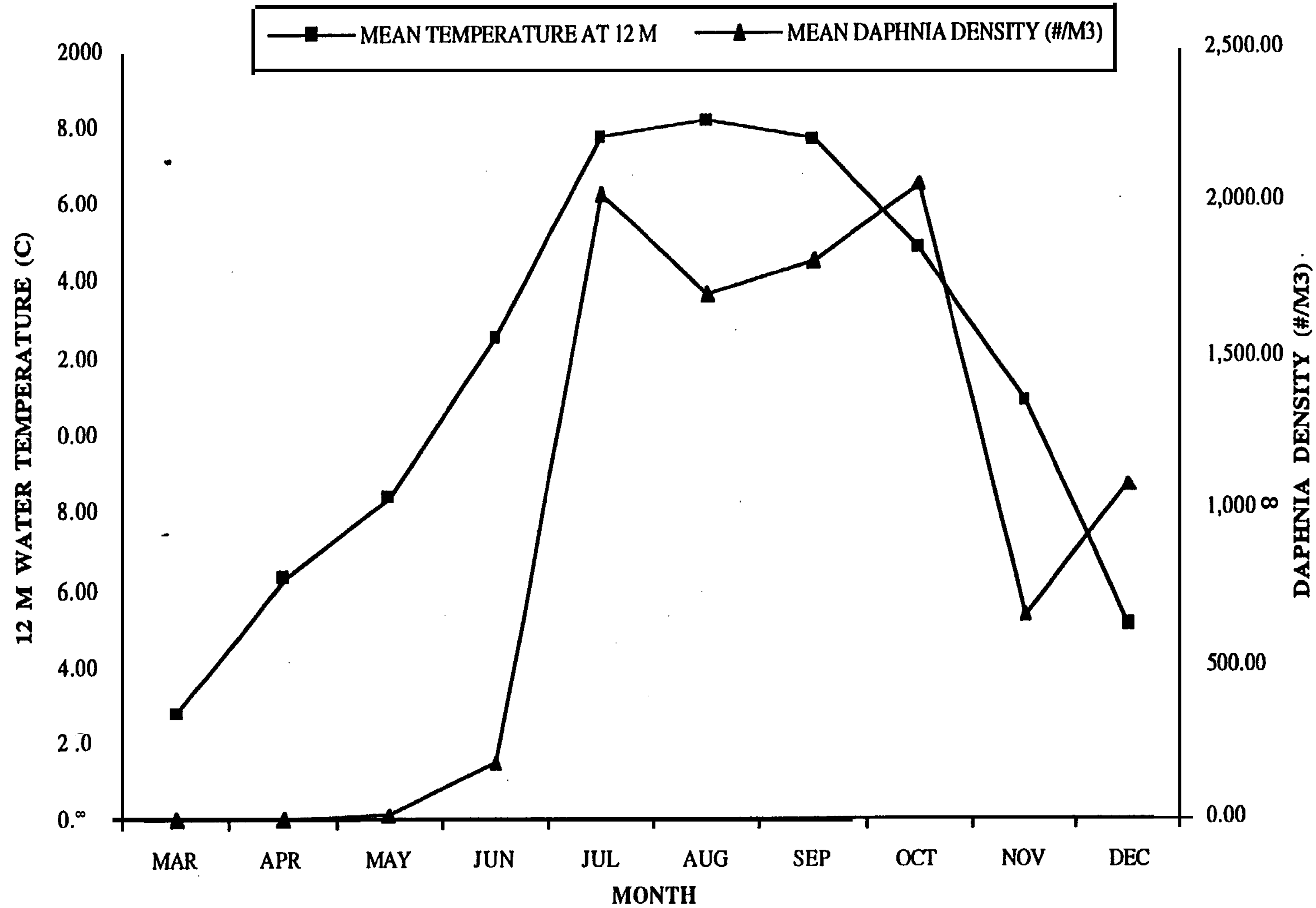


Figure 4.7 **Plot of mean *Daphnia* densities (#/m^3), versus mean water temperature at 12 m for Lake Roosevelt in 1996.**

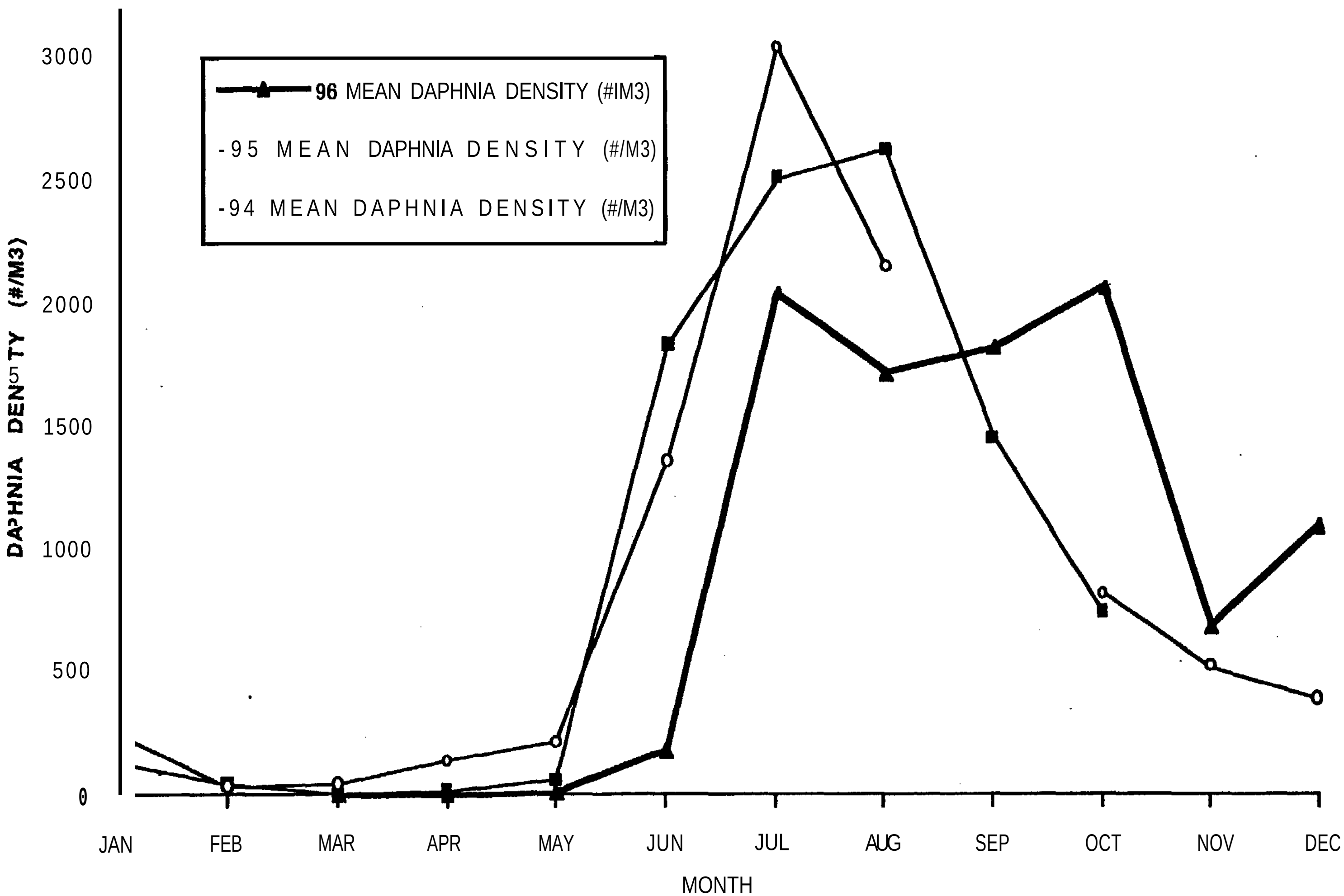


Figure 48 Plot of *Daphnia* densities (#/m^3) by month in Lake Roosevelt for the 1994, 1995 and 1996 sampling seasons.

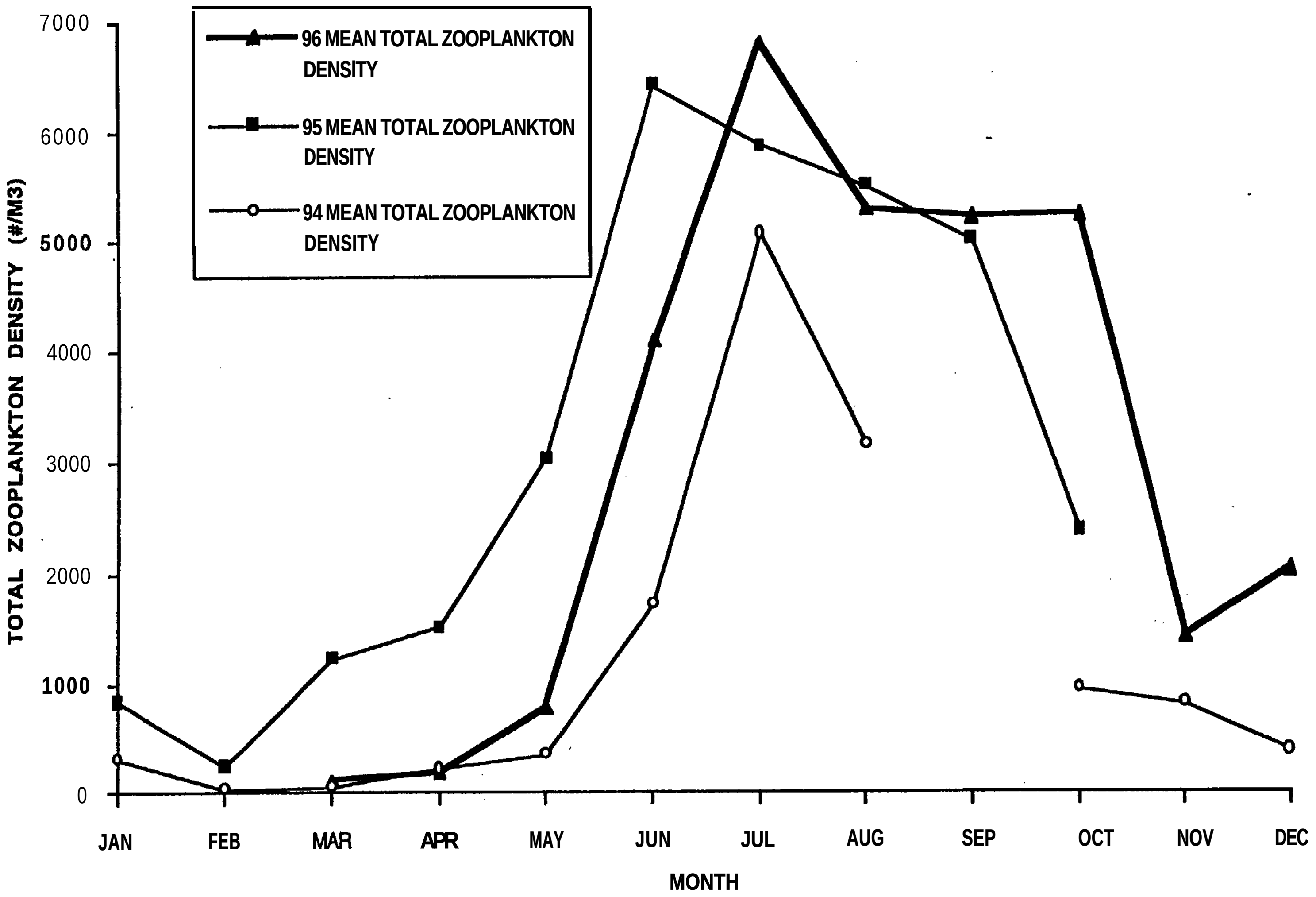


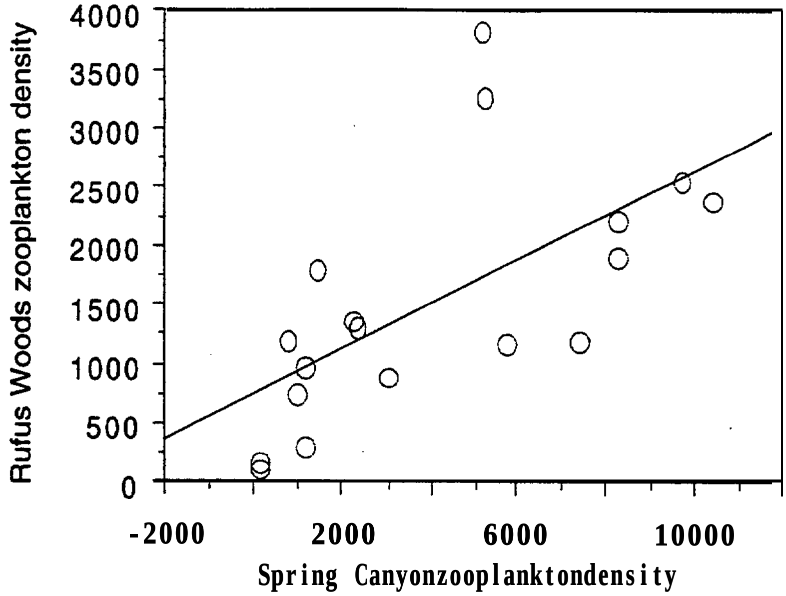
Figure 4.9 Plot of total zooplankton densities (#/m3) by month for Lake Roosevelt in 1994, 1995, and 1996.

abundance indicates that the coolest year (1996), had the highest total zooplankton abundance (Figures 4.4 and 4.9). Based on this data, it appears that cooler summer water temperatures alter zooplankton community composition in Lake Roosevelt and result in a decreased relative abundance of *Daphnia* spp. Decreased *Daphnia* spp. densities coupled with increases in total zooplankton densities may also influence the food base of kokanee salmon. Since larger zooplankton such *as Daphnia* spp. are most important in the diet of kokanee salmon (Table 3.46), higher densities of other taxa may not be fully utilized as a food source by kokanee salmon. Once community shifts have occurred, competition may exist between zooplankton which may maintain the community composition or induce further shifts.

Both *Daphnia* spp. and total zooplankton densities were much lower at Gifford (Location 2) than at other comparative sites within the reservoir during 1996 (Figures 4.5 and 4.6), supporting the idea that water temperature effects zooplankton production in Lake Roosevelt. Gifford is located on the upper arm of Lake Roosevelt and is commonly colder than other sampling sites. In 1996, summer average water temperatures at Gifford were approximately two degrees below reservoir averages during the summer (Appendix C).

As observed in previous years, the highest mean zooplankton densities and biomass occurred at the lower end of the Reservoir. The higher density values in this section are likely a result of the flushing of water through the reservoir resulting in a “pileup” of organisms at lower reservoir sites. Reductions in reservoir elevations and large releases from the dam may further impact zooplankton populations through entrainment. Yearly zooplankton entrainment rates, as measured in Rufus Woods reservoir, indicate that a yearly average of 1,570.9 organisms are entrained per cubic meter of water flowing through Grand Coulee Dam.

Zooplankton collected at Rufus Woods (below Grand Coulee Dam) have probably been entrained from Lake Roosevelt because high water velocities in the tailrace prevent the establishment of a ‘resident’ zooplankton community. A significant positive relationship ($r^2=0.41$; $p < 0.004$) existed between monthly total zooplankton densities at the Spring Canyon and Rufus Woods sampling locations during 1995 and 1996 (Figure 4.10). This relationship suggests that zooplankton densities at Rufus Woods can be used as an effective index of zooplankton entrainment rates from Lake Roosevelt. However, densities observed at Rufus Woods probably underestimate actual entrainment rates because an unknown level of zooplankton mortality occurs during entrainment.



Y=744.878+.19*X;R^2=.409

Figure 4.10 Regression plot of Spring Canyon and Rufus Woods monthly total zooplankton densities for 1995 and 1996.

Comparison of annual and seasonal zooplankton entrainment rates suggest that entrainment rates increase with higher annual runoff above Grand Coulee Dam, and that zooplankton entrainment rates are probably related to both water retention times and reservoir operations. More severe drawdowns in Lake Roosevelt probably increase entrainment rates in two ways. First, decreased water retention time resulting from increased runoff and/or greater drawdown probably increases zooplankton entrainment rates. In addition, penstocks for water withdrawal from Lake Roosevelt are located 150 and 250 feet below full pool elevation. Although zooplankton commonly exhibit vertical migrations (Bayly 1986; Hutchinson 1967), they are not generally abundant in very deep waters due to resource limitations (Weider and Lampert 1985). Under more severe drawdowns, the water discharged through Grand Coulee Dam is supplied from areas nearer the reservoir surface where zooplankton are generally most abundant, and zooplankton probably become more susceptible to entrainment under increased drawdown scenarios.

4.3 Rainbow Trout Tagging

The percentage of tagged fish recovered below Grand Coulee Dam is an indicator of entrainment rate, and has ranged from 0 to 89% over the past eight years, dependent on month when fish are released (Table 3.25). Water retention times below thirty days have been linked to increased entrainment rates of fish from Lake Roosevelt (Thatcher et al. 1993 and 1994; Griffith and Scholz 199 1), however our data suggests that entrainment rates are a function of both water retention times and drawdown/refill scenarios. Lake Roosevelt generally exhibits declining water levels during March and April, and increasing water levels during May and June. High entrainment rates of fish released during March and April generally occur when mean water retention times are less than 40 days (Table 3.25). In contrast, entrainment rates of fish released during May and June (during reservoir refill) are generally much lower under similar water retention times, with only moderate (16-19%) entrainment at water retention times down to 16 days (Table 3.25).

The relationship of both water retention times and drawdown/refill scenarios with estimates of entrainment are supported by our 1996 tagging data In 1996, estimated entrainment of rainbow trout tagged at Kettle Falls (89%) was the highest ever recorded by the Monitoring Program (Table 3.25). In April, 1996 breakage of a debris collecting log boom above Kettle Falls resulted in an inadvertent release of rainbow trout due to rips in the Kettle Falls net pens. During the release period water retention times averaged 18.6 days, and high entrainment rates from the Kettle Falls area are probably the result of premature releases during a period of declining reservoir elevation and low water retention time. In contrast, net pen operators were able to hold fish until the middle of June at Seven Bays, when water retention times and reservoir elevations were increasing (Appendix A). Estimated entrainment rate for the Seven Bays releases was lower than that of fish released from Kettle Falls, with only 16 percent (33 of 202 returns) captured below Grand Coulee Dam even though water retention times in June were similar (16 days) to those in April (Table 3.25).

Overall, entrainment rates from Lake Roosevelt appeared to be high for 1996, and examination of tag release location versus fish capture location indicates a large down lake migration of net pen rainbow trout from both release sites. Of tag returns from the Kettle Falls releases, 96% (n=25) were captured at down lake locations. The remaining 4% of fish (n=l) were captured in the Kettle Falls area (Table 3.26). No Kettle Falls fish were captured up lake from the release site. Tag returns from Seven Bays releases find that 67% (n=135) were captured downstream from the release location, 20% (n=40), were recaptured in the Seven Bays area and 8% (n=17), were recaptured up lake. This down lake migration may have been due to the fact that suitable food items were most abundant in the lower end of the reservoir, or it may have been due to a smoltification process. The stock of rainbow trout used for the supplementation program has been found to exhibit a smoltification process similar to that of steelhead trout and anadromous salmon (Muzi 1984; Scholz et al. 1985; White et al. 1991). These rainbow trout have evidenced an increase in thyroxin, increased silvering, increased osmoregulatory capability and an increase in downstream migratory behavior during the spring (A. Scholz, personal communication). Therefore, if fish are released in early spring, they may exhibit partial smoltification resulting in a tendency to travel downstream.

4.4 Historical Stocking and Lake Operations

Historically, stocking strategies and lake operations have been the two major factors effecting recruitment of hatchery origin rainbow trout and kokanee salmon into the Lake Roosevelt fishery. Stocking strategies are controlled by the Hatchery Coordination Team (Team), whereas lake operations are controlled by natural, political, and economic forces (runoff, flood control, power production, irrigation). Members from the WDFW, the Colville Confederated Tribes, and the Spokane Tribe of Indians make up the Team and are charged with determining size and numbers of fish to be stocked, the best times and locations to stock fish, and the most effective method(s) of stocking (e.g. by truck).

Historical stocking strategies are discussed in Section 1.2, and summanized here for rainbow trout (Table 4.2) and kokanee salmon (Table 4.3). In 1994 Tilson et al. (1995) recommended that fry releases for kokanee salmon be discontinued, and that kokanee salmon be released as yearlings. The recommendation was made based on tag return data showing increased survival of kokanee salmon released as yearlings relative to those released as fry. Hatcheries have therefore outplanted higher percentages of kokanee salmon as yearlings since 1995, and the shift has reduced the total number of kokanee salmon being stocked into Lake Roosevelt because yearlings require more space for hatchery rearing (Table 4.3). Stocking strategies for rainbow trout have historically involved net pen rearing to a yearling stage, and have therefore been unaffected by the recommendations of Tilson et al. (1995; Table 4.2).

Water retention times’ below 30 days apparently reduce zooplankton and fish densities in Lake Roosevelt through entrainment, thereby negatively impacting the fishery (Voeller 1996; Thatcher et al. 1993 and 1994; Peone et al. 1990; Griffith and Scholz 1991;). In general, lake elevations below 1,240 feet MSL coincide with water retention times below 30 days in Lake Roosevelt (Griffith and Scholz 1991; Thatcher et al. 1993 and 1994), however this is dependent on river flows and dam operations. Spring drawdowns in 1989 and 1991 resulted in water levels below 1,240 MSL and water retention times less than 30 days (Figures 4.1 and 4.2), and were considered particularly detrimental to the fishery (Peone et al. 1990; Griffith and Scholz 1991; Thatcher et al. 1993 and 1994; Griffith et al. 1995). In contrast 1992 through 1995 had higher mean water levels and water retention times, and were less detrimental to the fishery based on tag returns and creel results (Underwood et al. 1997). Extensive drawdown in 1996 resulted in conditions similar to those in 1991 in Lake Roosevelt with regard to lake elevations and water retention times (Figures 4.1 and 4.2). In 1996, water levels averaged less than 1,240 feet MSL in both April and May, and monthly mean water retention times were less than 30 days from March through July.

4.5 Creel Survey Trends

In 1996, the estimated number of angler trips to Lake Roosevelt and the economic value of the fishery were lower than in any year since 1991 (Table 4.4). The economic value of the Lake Roosevelt fishery in 1996 was approximately $1.1 million less than in 1995, and approximately one third of the estimated value of the fishery in 1993 and 1994 (Table 4.4). The estimated annual number of angler trips to Lake Roosevelt peaked in 1993 and has been declining since (Table 4.4). The estimated number of angler trips made in 1996 was approximately one third of the 1993 estimate, and was reduced nearly 25% from 1995 (Table 4.4). Reductions in the number of angler trips in 1996 (Table 4.4) was potentially a result of dewatering of boat ramps during the spring drawdown which prohibited anglers from accessing much of Lake Roosevelt during the spring.

4.5.1 Rainbow trout

The rainbow trout stocked from net pens recruit into the fishery in the same year as being stocked, and the majority of rainbow trout are harvested that same year (Peone et al. 1990, Griffith and Scholz 1991, Griffith et al. 1995, Griffith and McDowel 1996, Voeller 1996, Thatcher et al. 1993, and 1994). Estimates of rainbow trout catch and harvest showed an increasing trend from 1990 through 1994, followed by a notable decline through 1996. Based on our creel data, estimated catch and harvest of rainbow trout in 1996 was the lowest since 1990 (Table 4.4).

Table 4.2 **Summary of hatchery origin rainbow trout released into Lake Roosevelt from 1986 though 1996.**

Year	Hatchery	Number
1986	Spokane (WDFW)	50,000
1987	Spokane (WDFW)	80,000
1988	Spokane (WDFW)	150,000
1989	Spokane (WDFW)	175,000
1990	Spokane (WDFW)	276,500
1991	Spokane Tribal	326,461
1992	Spokane Tribal	424,395
1993	Spokane Tribal	446,798
1994	Spokane Tribal	449,183
1995	Spokane Tribal	415,844
1996	Spokane Tribal	576,853

Table 4.3 Summary of hatchery origin kokanee salmon released into Lake Roosevelt from 1988 though 1996.

Year	Hatchery	Number	Life Stage	Size (#/lb)
1988	Ford	872,150	fry	500
1989	Ford	861,442	fry	280
1990	Ford	1,025,400	fry	247
1991	Spokane Tribal	1,674,577	fry	119
1992	Spokane Tribal	71,256	yearling	9
1992	Spokane Tribal	819,220	fry	158
1992	Sherman Creek	68,552	yearling	22
1992	Sherman Creek	1,099,000	fry	616[a]
1993	Spokane Tribal	21,190	yearling	7
1993	Spokane Tribal	1,024,293	fry	225
1993	Sherman Creek	72,508	yearling	15
1993	Sherman Creek	675,572	fry	228
1994	Spokane Tribal	123,254	yearling	10
1994	Spokane Tribal	1,910,255	fry	125
1994	Sherman Creek	90,881	yearling	11[a]
1994	Sherman Creek	1,087,161	fry	372[a]
1995	Spokane Tribal	1,401	brood	1
1995	Spokane Tribal	59,825	yearling	10
1995	Spokane Tribal	515,425	fry	202
1995	Sherman Creek	210,643	yearling	15[a]
1995	Sherman Creek	164,328	yearling	28[a]
1996	Spokane Tribal	54,194	yearling	9
1996	Sherman Creek	224,562	yearling	14[a]
1996	Sherman Creek	50,899	fry	52[a]

[a] size transferred from Spokane Tribal Hatchery, not at release.

Table 4.4 Summary of angler trips, number of fish caught and harvested, catch and harvest per unit of effort and mean lengths of kokanee salmon, rainbow trout and walleye from 1990 through 1996.

	1990	1991	1992	1993	1994	1995	1996
Economic Value							
(millions of dollars)	5.3	12.8	9.7	20.7	19.1	8.7	7.6
Angler Trips	171,725	398,408	291,380	594,508	469,998	232,202	176,763
No. Caught							
kokanee	17,756	31,651	8,146	13,986	16,567	32,353	1,265
rainbow	81,560	81,529	167,156	402,277	499,460	125,958	76,915
walleye	116,473	231,813	163,995	337,413	123,612	73,667	142,873
No. Harvested							
kokanee	17,515	31,651	8,021	13,960	16,567	32,353	1,265
rainbow	79,683	73,777	140,609	398,943	499,293	122,939	76,782
walleye	82,284	168,736	118,863	307,663	53,589	40,185	104,055
CPUE							
kokanee	0.03	0.06	0.03	0.01	<0.01	0.02	<0.01
rainbow	0.13	0.20	0.22	0.17	0.21	0.08	0.10
walleye	0.11	0.11	0.15	0.12	0.08	0.13	0.30
HPUE							
kokanee	0.02	0.06	0.03	0.01	<0.01	0.02	<0.01
rainbow	0.12	0.20	0.18	0.16	0.21	0.08	0.10
walleye	0.08	0.08	0.11	0.08	0.05	0.06	0.16
Mean Length							
kokanee	391	361	436	486	481	467	438
rainbow	346	348	422	471	473	410	363
walleye	376	397	361	382	385	370	372

Rainbow trout catch and harvest rates (CPUE and HPUE) in 1995 and 1996 were lower than in previous years (Table 4.4) with two possible explanations. Underwood et al. (1997) suggested that either catch and harvest of rainbow trout was overestimated or overfishing of rainbow trout occurred during in 1993 and 1994. Reduced mean length of rainbow trout in 1995 and 1996 relative to 1993 and 1994 (Table 4.4) may indicate that overharvest did occur in 1993 and 1994 (Underwood et al. 1997), and has resulted in fewer fish of older age (and increased size) being harvested recently. Recent declines in catch and harvest rates may also be a result of fewer older rainbow trout in the fishery, and may support the hypothesis of overharvest in earlier years.

Another hypothesis for decreased catch and harvest rates in 1996 is related to entrainment of rainbow trout due to increased severity of spring drawdown. Decreased water retention time (a result of drawdown) have been related to entrainment of rainbow trout through Grand Coulee Dam (Thatcher et al. 1994; Griffith and McDowel 1996). Our tag return data suggests that entrainment rates were high in 1996, with 25 percent of tags returned from 1996 releases coming from below Grand Coulee Dam, including 88.5 percent of those from April releases (i.e. during peak drawdown; Table 3.25). Estimates of entrainment since 1989 suggest that entrainment rates were also high (up to 63%) from 1989 through 1991 (Table 3.25). Entrainment rates from 1992 through 1995 were lower than in 1996, ranging from O-3 percent (Table 3.25). Minimum reservoir elevations in 1989, 1991, and 1996 were below 1,230' MSL whereas from 1992 through 1995 drawdowns were less severe and resulted in minimum water levels above 1250' MSL. Reservoir operations during 1996 were similar to those in 1989 and 1991, and increased entrainment of rainbow trout in these years is probably related to increased severity of spring drawdowns in Lake Roosevelt.

4.5.2 Kokanee Salmon

Kokanee salmon abundance in Lake Roosevelt appears to be highly variable, and has been related to entrainment rates and water retention times (Underwood et al. 1997; Underwood et al. 1996). Creel survey data in 1996 indicates lower abundance of kokanee salmon than in previous years (Table 4.4), whereas electrofishing and gillnet surveys indicated an increased abundance in 1996 relative to previous years (Tables 4.5 and 4.6).

We believe that creel survey data best represents trends in the fishery because it most accurately reflects what is occurring in the lower reservoir where kokanee salmon are typically most abundant. Kokanee salmon normally inhabit the lower reaches of Lake

Table 4.5 Comparison of relative abundance (%) of fish collected during the 1989 through 1996 sampling periods via electroshocking and gillnetting.

	1989	1990	1991	1992	1993	1994	1995	1996
Effort (hrs)	482	**581**	366	436	**100**	643	2,099	1,535
bridgelip sucker	1	<I	<1	**<1**	0	c l	1	**2**
brook trout	<1	<1	<1	<1	<1	<1	<1	<1
brown bullhead	0	<1	<1	<1	<1	<1	<1	<1
brown trout	<1	<1	<1	<1	<1	<1	<1	2
bull trout	c l	0	0	0	0	<1	<1	0
burbot	<1	<1	<1	<1	<1	1	<1	4
carp	2	2	<1	2	1	1	2	2
chinook salmon	<1	<1	<1	<1	<1	<1	<1	0
chiselmouth	0	c l	0	0	0	0	0	0
cottus spp.	2	2	<1	2	3	16	6	<1
crappie	<1	<1	<1	<1	0	<1	<1	<1
cutthroat trout	0	0	0	0	0	0	0	C l
kokanee salmon	2	<1	<1	3	<1	3	20	4
lake whitefish	4	3	<1	1	<1	2	5	7
largemouth bass	<1	<1	<1	0	0	0	0	<1
largescale sucker	12	19	34	43	45	35	27	39
longnose sucker	<1	2	<1	<1	0	2	<1	1
mountain whitefish	<1	<1	<1	<1	<1	<1	<1	<1
peamouth	<1	0	<1	<1	0	0	0	0
pumpkinseed	<1	<1	0	0	0	-2	0	0
rainbow trout	5	3	5	6	9	<1	5	7
redside shiner	0	<1	0	0	0	<1	<1	0
smallmouth bass	2	3	15	11	9	8	10	6
squawfish	4	5	3	2	8	4	2	2
sturgeon	<1	0	0	0	0	0	0	0
Catostomus spp.	7	0	0	0	0	0	<1	2
tench	<1	<1	<1	<1	0	<1	<1	<1
walleye	18	13	12	11	11	7	12	19
yellow bullhead	<1	0	0	0	0	0	0	0
yellow perch	40	45	29	17	11	12	7	2

Table 4.6 Comparison of catch per unit effort (No. fish per hour) for fish collected during the 1989 through 1996 sampling periods via electroshocking and gillnetting.

	1989	1990	1991	1992	1993	1994	1995	1996
Effort (hrs)	482	581	366	436	100	643	2,099	1,535
bridgelip sucker	0.21	0.01	0.03	< 0.01	0.00	<0.01	0.06	0.04
brook trout	0.01	<0.01	<0.01	0.01	0.02	0.02	0.01	0.02
brown bullhead	0.00	<0.01	<0.01	0.07	0.03	0.00	0.00	<0.01
brown trout	0.04	0.03	0.04	0.04	0.16	0.03	0.02	0.04
bull trout	<0.01	0.00	0.00	0.00	0.00	<0.01	0.01	0.00
burbot	0.06	0.02	0.05	0.02	0.03	‘0.14	0.04	0.09
carp	0.24	0.26	0.20	0.15	0.22	0.19	0.11	0.04
chinook salmon	<0.01	<0.01	0.01	0.01	0.01	<0.01	<0.01	0.00
chiselmouth	0.00	<0.01	0.00	0.00	0.00	0.00	0.00	0.00
cottus spp.	0.27	0.22	0.06	0.16	0.62	2.13	0.27	0.02
cutthroat trout	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<0.01
crappie	0.09	0.02	<0.01	0.04	0.00	0.01	**0.00**	**<0.01**
kokanee salmon	0.27	0.10	0.08	0.28	0.15	0.46	0.98	0.09
lake whitefish	0.56	0.38	0.20	0.10	0.15	0.26	0.25	0.13
largemouth bass	0.10	0.05	0.01	0.00	0.00	0.00	0.00	<0.0.1
largescale sucker	1.87	2.85	7.51	3.91	10.12	4.76	1.30	0.78
longnose sucker	0.04	0.32	0.01	0.01	0.00	0.26	0.02	0.03
mountain whitefish	0.03	0.03	0.08	0.01	0.02	0.01	0.01	<0.01
peamouth	0.03	0.00	<0.01	0.01	0.00	0.00	0.00	0.00
pumpkinseed	0.01	0.10	0.00	0.00	0.00	0.20	0.00	0.00
rainbow trout	0.82	0.43	1.02	0.56	2.03	0.88	0.24	0.14
redside shiner	0.00	<0.01	0.00	0.00	0.00	0.01	<0.1	0.00
smallmouth bass	0.24	0.46	3.22	1.01	2.08	1.12	0.46	0.12
squawfish	0.61	0.80	0.59	0.21	1.84	0.49	0.11	0.04
sturgeon	<0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Catostomus spp.	0.99	0.00	0.00	0.00	0.00	0.00	0.00	0.03
tench	0.01	0.03	0.01	0.01	0.00	0.02	<0.01	<0.01
walleye	2.70	1.96	2.60	0.99	2.34	1.00	0.58	0.39
yellow bullhead	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
yellow perch	6.02	6.65	6.40	1.55	2.48	1.63	0.34	0.03
TOTALS	15.24	14.73	22.13	9.15	22.29	13.61	4.79	2.01

Roosevelt during the majority of the year, and the kokanee salmon fishery in Lake Roosevelt has historically concentrated in Section 3 (lower reservoir). Creel data showed angler catch of kokanee salmon in 1996 was entirely from Section 3, with 87.5 percent caught in January and the remainder in March (Appendix D). Our gillnet and electrofishing surveys typically collect few kokanee salmon except during fall when they move upstream and concentrate in spawning areas. During 1996 kokanee salmon were collected primarily from Sections 1 and 2 by electrofishing (96 %) and gillnetting (87 %), with the majority (96 and 69 %, respectively) collected in October. Our low harvest estimate of kokanee salmon in 1996 (1,265 kokanee) agrees with low angler catch and harvest rates, further substantiating the idea that creel survey data probably best represents trends in kokanee salmon abundance in Lake Roosevelt.

Angler catch and harvest rates since 1990 show a variable trend in kokanee salmon abundance, with low abundance in 1993,1994 and 1996, high abundance in 1991, and moderate abundance in other years (Table 4.4). Based on creel data, kokanee salmon harvest was lower in 1996 than any year since 1989, and angler catch and harvest occurred entirely before the spring drawdown. The 1996 drawdown may have significantly impacted the kokanee salmon population in Lake Roosevelt, probably through entrainment of fish through Grand Coulee Dam. Tilson et al. '(1994) and Scholz et al. (1992 and 1993) found that yearling kokanee salmon go through a partial smoltification phase during April that results in an increased tendency to migrate downstream. The increased migration tendency coincides with the peak of annual spring drawdown in most years and may result in increased entrainment rates relative to other fishes. Underwood et al. (1996 and 1997) suggested that entrainment of kokanee salmon from Lake Roosevelt may exceed that of rainbow trout, especially in years of substantial drawdown.

Kokanee salmon do not enter the creel until they are approximately 300 mm in length and two years of age (Underwood et al. 1997), suggesting that major entrainment events of yearlings should be recognized in the following year, whereas those involving mixed age classes may have a more immediate impact on the fishery. The major decline in kokanee salmon harvest in 1996 suggests that kokanee salmon of all ages were potentially entrained in high numbers during the spring drawdown. This will be further substantiated if harvest rates remain low in 1997, suggesting high entrainment rates of yearling kokanee salmon during the 1996 drawdown. In addition, hydroacoustic surveys currently being conducted by the Colville Tribe will provide information on entrainment of kokanee salmon and other fishes from Lake Roosevelt and help to define the relationship between entrainment rates and reservoir operations.

Mean length of kokanee salmon observed in the creel increased between 1990 and 1993, and has declined from 1993 through 1996 (Table 4.4). Kokanee salmon growth in Lake Roosevelt may be limited in some years by food (zooplankton) production and availability Our data suggests that reductions in spring water retention times may delay zooplankton production in Lake Roosevelt, thereby reducing the length of the growing season for kokanee salmon. Reductions in zooplankton density appear to be related to water retention times less than 30 days in Lake Roosevelt (Peone et al. 1990; Beckman et al. 1985), and severity of the 1996 drawdown contributed to monthly mean water retention times less than 30 days from March through July. Preliminary analysis shows a significant positive relationship between mean length of kokanee salmon in the creel and mean water retention times during March ($r^2=0.606$; $P<0.001$ and April ($r^2=0.535$; $P=0.04$) from 1989 through 1996. Zooplankton density in Lake Roosevelt typically remains low throughout the winter, increases beginning in March-April, and peaks from June through September (Shields and Underwood 1996; Shields and Underwood 1997). Zooplankton densities generally increase earliest at downstream locations (Section 3) where they peak in June (Shields and Underwood 1996; Shields and Underwood 1997). In 1996, zooplankton abundance in Section 3 remained at typical winter levels until May and did not peak until July, probably reducing food availability for kokanee salmon during the early portions of the growing season.

4.5.3 Walleye

Similarly to previous years, catch estimates and rates for walleye exceeded our estimates of annual harvest and harvest rates. A slot limit exists for walleye in Lake Roosevelt, allowing harvest of walleye under 16 inches or over 20 inches in length. The slot limit results in anglers releasing intermediate sized walleye, and leads to catch rates exceeding harvest rates in all years. Similarity in CPUE and HPUE between years since 1990 (Table 4.4) suggests that the proportion of walleye caught outside of the legal size range has remained relatively constant since 1990.

Walleye CPUE and HPUE in 1996 were higher than all years previously examined. However estimated angler catch and harvest (numbers) were lower than those in 1991 through 1993 (Table 4.4). Angler pressure (number of angler trips) was lower in 1996 than most previous years, allowing for the high catch rates and moderate catch numbers noted in 1996.

Walleye CPUE and HPUE increased from 1990 through 1992, then declined until 1994, increasing again through 1996 (Table 4.4). Mean length of walleye harvested has generally followed an inverse trend, suggesting that in years of increased walleye harvest, smaller fish comprise a higher percentage of the creel. Higher percentages of small walleye corresponding to increased harvest estimates may indicate recruitment of relatively strong year classes to the fishery. Based on 1995 and 1996 harvest data, walleye appear to recruit to the fishery between 350 and 400 mm total length, corresponding to walleye 3 to 4 years of age. No data is currently available on relative strength of walleye cohorts in Lake Roosevelt although our data suggests a particularly strong year class from 1989 or 1990 (1993 harvest) and a relatively weak year class in 1991 or 1992 (1995 harvest). Preliminary length frequency analysis of walleye cohorts also suggests that a weak year class was produced in Lake Roosevelt during 1992. Further data analysis will be necessary to determine factors that affect survival and recruitment of walleyes in Lake Roosevelt.

4.5.4 Smallmouth bass

Approximately 3 percent of smallmouth bass caught by anglers in Lake Roosevelt during 1996 were harvested. Catch and harvest rates for smallmouth bass have become increasingly divergent since at least 1993. Catch rates have remained relatively consistent, ranging from 0.40 (1995) to 0.96 (1994), while harvest rates have decreased steadily from 0.06 in 1993 to <0.001 in 1996. The percentage of anglers targeting 'other species' (including smallmouth bass) has remained relatively constant (5 to 10%) during the same period. Decreasing harvest rates and consistent catch rates and pressure suggest that smallmouth bass are; 1) becoming recognized as a 'catch and release' sport fish in Lake Roosevelt, and/or 2) becoming increasingly viewed as an undesirable incidental catch by anglers specifically targeting other species. It is more likely that smallmouth bass are primarily considered an incidental catch in Lake Roosevelt because the percentage of anglers targeting them has been consistently low since 1989.

4.6 Relative Abundance

Relative abundance of fish species in Lake Roosevelt has remained relatively consistent since '1989 with that of only a few species changing appreciably (Table 4.5). Both overall and species specific CPUE were reduced considerably in 1996 relative to previous years (Table 4.6) potentially as a result of increased entrainment and decreased sampling efficiencies during a relatively high water year. Largescale suckers have been abundant in our electrofishing and gillnet catches since 1989, and have been the dominant taxon since 1991 (Tables 4.5 and 4.6). Yellow perch were the dominant taxon in 1989 and 1990, but have declined dramatically in relative abundance (and CPUE) since 1990 (Tables 4.5 and 4.6). Abundance of kokanee salmon in our 1996 surveys decreased substantially since 1995 when relative abundance of kokanee salmon was at an historic high. Kokanee salmon relative abundance in 1996 was comparable to 1992 and 1994, and higher than all other years except 1995 (Table 4.5). Rainbow trout relative abundance has been variable since 1989, and were slightly higher in 1996 than in 1995 (Table 4.5). Both CPUE and relative abundance of burbot in our collections were increased in 1996 relative to most previous years (Tables 4.5 and 4.6). Based on our electrofishing and gillnet surveys, both relative abundance and CPUE of other species has remained relatively constant since 1989 (Tables 4.5 and 4.6).

Similar trends in fish abundance represented by various indices suggests that our data accurately represent long term trends occurring in Lake Roosevelt. Both relative abundance and CPUE indices can be affected by location, timing, and duration of sampling efforts however, trends in CPUE for gillnet and electrofishing surveys (Table 4.6) have been similar to those noted in our relative abundance data (Table 4.5) since 1989.

4.7 Growth and Feeding.

Peone et al. (1990) used back calculated length at age to compare growth of kokanee salmon, rainbow trout, and walleye in Lake Roosevelt to that in other northern lakes. Kokanee salmon and rainbow trout sampled from Lake Roosevelt have historically had higher growth rates than the averages reported by Peone et al. (1990), and the same was true in 1996. Growth rates of kokanee salmon and rainbow trout in Lake Roosevelt have not changed appreciably since 1989. In contrast, growth rates of walleye in Lake Roosevelt appear to be declining over time. Growth rates of Lake Roosevelt walleye were above average until approximately 199 1, and have been declining steadily since (Tables 3.19 and 4.4).

The feeding habits of rainbow trout and kokanee salmon in Lake Roosevelt have not changed appreciably since 1989. Rainbow trout and kokanee salmon feed primarily on *Daphnia* spp. and chironomids, exhibiting consistently high dietary overlap since 1989 (0.72 in 1996). Walleye in Lake Roosevelt feed primarily on fish as adults and chironomids as juveniles, and their dietary overlap with kokanee salmon (0.07) and rainbow trout (0.35) was relatively low in 1996 and similar to overlap estimates from previous years.

Diet overlap helps to identify species that would potentially compete for food if food was limited. If food was limited we would expect to see a decrease in growth rates or poor condition factors, neither of which has been observed for kokanee salmon or rainbow trout in Lake Roosevelt. In contrast, our analysis of walleye growth and diet suggests that availability of preferred foods may be limiting walleye growth in Lake Roosevelt. Declines in yellow perch abundance (Table 4.5) and their importance in walleye diet coupled with a coincidental decrease in walleye growth (3.45 and 4.4) suggests that yellow perch have been the preferred food of walleye in Lake Roosevelt. Therefore, walleye growth appears to be at least partially limited by yellow perch availability. The IRI values calculated for walleye show a decreasing importance of yellow perch (21.99 to 5.35) and an increasing importance of salmonids (1.29 to 28.3 1) and other fish since 1990. However, IRI values only estimate the relative importance of food sources and are not indicative of trends in numbers consumed.

Size selection of zooplankton is occurring in the diets of both kokanee salmon and rainbow trout in Lake Roosevelt, although size selection differs between the two species (Tables 3.47 and 3.48). Kokanee appear to utilize smaller *D. pulex than* rainbow trout, with positive electivity values beginning at the 1.3-1.5 mm size range for kokanee salmon (Table 3.47). In contrast, positive electivity values begin at the 1.9 to 2.1 mm size range for rainbow trout (Table 3.48). Differential size selection of zooplankton by kokanee and rainbow trout may reduce the potential for competition between these two species during periods of low zooplankton abundance in Lake Roosevelt.

5.0 RESEARCH NEEDS AND MANAGEMENT RECOMMENDATIONS

5.1 RESEARCH NEEDS

1. Continue zooplankton, water quality, and fisheries monitoring as described in previous reports.

2. Develop a bathymetric map of Lake Roosevelt in a GIS system and collect data to build a map layer for vegetation (shoreline and aquatic), structure and substrate type. This map will be used to determine changes in available littoral habitat under various drawdown scenarios.

3. Collect additional information on turbidity, dissolved gasses, chlorophyll a, nutrients, and metal concentrations in Lake Roosevelt to examine the relationship between water quality and primary production.

4. Conduct C^{14} studies to examine nutrient assimilation rates by phytoplankton.

5. Determine the depth of the euphotic zone via photometer to estimate the availability of phytoplankton habitat.

6. Investigate periphyton dynamics to further assess primary production.

7. Increase the temporal and spatial intensity of zooplankton and water quality sampling to better relate the effects of reservoir operations to zooplankton production.

8. Estimate potential and realized zooplankton production within Lake Roosevelt by comparison of life history parameters observed in mesh enclosures and the open waters of Lake Roosevelt.

9. Continue investigations into the relationship between zooplankton production and variations in growth of kokanee salmon.

10. Establish strength of past walleye cohorts through length frequency analysis to determine if variations in mean length are related to cohort strength or other factors.

11. Index white sturgeon to establish basic population parameters (condition, age composition, etc.) in Lake Roosevelt.

12. Explore the viability of shifting towards a boat based creel survey to contact more anglers and improve accuracy of creel estimates.

13. Begin floy tagging 10,000 kokanee salmon smolts in an attempt to increase angler returns of tagged kokanee salmon and assess the success of various release strategies.

14. Conduct boat based hydroacoustic surveys to examine variations in die1 and spatial distribution of kokanee salmon and rainbow trout.

5.2 MANAGEMENT RECOMMENDATIONS

1. Continue to hold net pen rainbow trout until after maximal drawdown is reached to minimize entrainment. Entrainment rates appear to be reduced during periods of increasing water levels.

2. Operate Lake Roosevelt as indicated in the Northwest Power Planning Council Fish and Wildlife Program (amended in September, 1995). This program recommends maintenance of water levels above 1,250 feet above mean sea level and water retention times above 30 days.

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APPENDIX A

Hydrology

Table A.1 Daily midnight reservoir inflow, outflow, elevation, storage capacity, and water retention time for Lake Roosevelt in January, 1996. Data from CORPs daily summary ‘reports.

JANUARY

Day of Month	Reservoir Inflow (kcfs)	Reservoir outflow (kcfs)	Reservoir Elevation (Ft)	Reservoir Storage (ksfd)	Water Retention Time (Days)
1	123.8	92.0	1,284.7	4,376.3	47.6
2	129.9	122.0	1,284.9	4,384.2	35.9
3	120.1	116.1	1,285.0	4,388.2	37.8
4	136.5	128.5	1,285.2	4,396.2	34.2
5	125.7	145.6	1,284.7	4,376.3	30.1
6	120.3	135.3	1,284.3	4,360.4	32.2
7	125.0	105.3	1,284.7	4,376.3	41.6
8	136.5	135.9	1,284.7	4,376.3	32.2
9	123.2	151.1	1,284.0	4,348.5	28.8
10	143.6	147.6	1,283.9	4,344.6	29.4
11	154.0	152.0	1,284.0	4,348.5	28.6
12	155.0	164.8	1,283.7	4,336.7	26.3
13	142.1	155.9	1,283.4	4,324.8	27.7
14	141.5	145.4	1,283.3	4,320.9	29.7
15	142.8	172.1	1,282.5	4,289.5	24.9
16	141.4	151.1	1,282.3	4,28 1.7	28.3
17	145.3	147.3	1,282.2	4,277.8	29.0
18	146.3	181.2	1,281.3	4,242.9	23.4
19	136.9	171.6	1,280.4	4,208.2	24.5
20	142.5	175.0	1,279.6	4,177.5	23.9
21	160.1	154.4	1,279.7	4,181.4	27.1
22	169.0	184.2	1,279.3	4,166.1	25.2
23	168.2	181.5	1,279.0	4,150.8	22.9
24	159.9	173.2	1,278.6	4,139.4	23.9
25	171.4	175.2	1,278.5	4,135.6	23.6
26	162.0	178.4	1,278.1	4,120.5	23.1
27	168.9	163.5	1,278.0	4,116.7	25.2
28	176.7	139.0	1,278.7	4,143.2	29.8
29	182.5	177.6	1,278.8	4,147.0	23.4
30	173.5	183.0	1,278,6	4,139.4	22.6
31	178.2	197.0	1,278.1	4,120.5	20.9
Average	**148.5**	**154.9**	**1,281.7**	**4,261.2**	**28.4**

Table A.2 Daily midnight reservoir inflow, outflow, elevation, storage capacity, and water retention time for Lake Roosevelt in February, 1996. Data from CORPs daily summary reports.

			FEBRUARY		
Day of Month	**Reservoir Inflow (kcfs)**	**Reservoir Outflow (kcfs)**	**Reservoir Elevation (Ft)**	**Reservoir Storage (ksfd)**	**Water Retention Time (Days)**
1	167.2	192.6	1,277.4	4,094.0	21.3
2	163.5	192.5	1,276.6	4,063.8	21.1
3	153.1	166.6	1,276.0	4,041.3	24.3
4	150.2	132.5	1,276.2	4,048.8	30.6
5	148.0	135.3	1,276.5	4,060.1	30.0
6	167.6	141.3	1,277.2	4,086.4	28.9
7	145.8	103.4	1,278.3	4,128.0	39.9
8	140.8	50.4	1,280.6	4,215.9	83.6
9	126.7	54.7	1,282.5	4,289.5	78.4
10	116.0	56.8	1,283.9	4,344.6	76.5
11	143.6	116.2	1,284.4	4,364.4	37.6
12	154.8	158.2	1,284.2	4,356.4	27.5
13	178.4	173.7	1,284.3	4,360.4	25.1
14	198.9	184.6	1,284.5	4,368.3	23.7
15	204.6	185.2	1,284.4	4,364.4	23.6
16	209.5	189.3	1,284.0	4,348.5	23.0
17	193.7	178.4	1,283.5	4,328.8	24.3
18	179.7	155.0	1,283.1	4,313.1	27.8
19	173.9	152.0	1,283.1	4,313.1	28.4
20	180.4	161.5	1,283.3	4,320.9	26.8
21	172.6	175.0	1,283.0	4,309.1	24.6
22	185.3	165.0	1,283.2	4,3 17.0	26.2
23	185.0	184.6	1,282.5	4,289.5	23.2
24	170.5	178.0	1,280.9	4,227.4	23.7
25	165.2	173.4	1,279.6	4,177.5	24.1
26	167.0	189.6	1,278.2	4,124.3	21.8
27	183.7	195.4	1,277.1	4,082.6	20.9
28	159.8	196.7	1,275.4	4,018.8	20.4
Average	**167.3**	**154.9**	**1,280.9**	**4,227.0**	**31.7**

Table A.3 Daily midnight reservoir inflow, outflow, elevation, storage capacity, and water retention time for Lake Roosevelt in March, 1996. Data from CORPs daily summary reports.

MARCH

Day of Month	Reservoir Inflow (kcfs)	Reservoir Outflow (kcfs)	Reservoir Elevation (Ft)	Reservoir Storage (ksfd)	Water Retention Time (Days)
1	150.6	162.1	1,273.4	**3,944.5**	24.3
2	144.7	137.0	1,273.0	**3,929.7**	28.7
3	131.6	131.8	1,272.4	**3,907.6**	29.6
4	130.0	153.2	1,271.2	3,863.7	25.2
5	152.0	184.2	1,270.2	3,827.2	20.8
6	130.3	169.5	1,268.9	3,780.2	22.3
7	136.5	171.0	1,267.7	3,737.0	21.9
8	129.0	156.0	1,266.6	3,697.6	23.7
9	130.7	142.7	1,265.5	3,658.5	25.6
10	127.4	118.2	1,264.9	3,637.3	30.8
11	134.6	147.7	1,263.8	3,598.5	24.4
12	133.8	156.5	1,262.7	3,560.0	22.7
13	132.6	148.2	1,261.2	3,507.8	23.7
14	136.1	155.0	1,260.0	3,466.3	22.4
15	133.4	142.3	1,258.9	3,428.6	24.1
16	144.8	155.9	1,258.0	3,397.9	21.8
17	125.7	117.0	1,257.8	3,391.1	29.0
18	113.1	148.2	1,256.6	3,350.5	22.6
19	106.7	151.1	1,254.9	3,296.6	21.8
20	120.2	134.1	1,254.2	3,270.3	24.4
21	118.8	135.8	1,253.2	3,237.3	23.8
22	117.9	147.2	1,252.1	3,201.2	21.7
23	112.5	138.7	1,251.1	3,168.6	22.8
24	118.0	139.4	1,250.3	3,142.7	22.5
25	114.1	152.7	1,249.1	3,104.1	20.3
26	114.1	148.5	1,248.0	3,068.9	20.7
27	116.7	158.2	1,246.6	3,024.6	19.1
28	103.5	131.7	1,245.7	2,996.3	22.8
29	105.2	108.3	1,245.6	2,993.1	27.6
30	108.0	117.4	1,245.3	2,983.8	25.4
31	105.7	118.2	1,244.9	2,971.3	25.1
Average	**125.1**	**144.4**	**1,258.5**	**3,424.0**	**23.9**

Table A.4 Daily midnight reservoir inflow, outflow, elevation, storage capacity, and water retention time for Lake Roosevelt in April, 1996. Data from CORPs daily summary reports.

APRIL					
Day of Month	Reservoir Inflow (kcfs)	Reservoir Outflow (kcfs)	Reservoir Elevation (Ft)	Reservoir Storage (ksfd)	Water Retention Time (Days)
1	104.4	128.3	1,244.l	**2,946.4**	23.0
2	102.3	122.1	1,243.4	**2,924.8**	24.0
3	105.2	131.8	1,242.l	2,884.8	21.9
4	97.3	124.1	1,240.8	2,845.2	22.9
5	104.4	117.8	1,240.0	2,821.0	23.9
6	112.0	122.4	1,239.l	2,794.0	22.8
7	114.4	122.0	1,238.0	2,761.2	22.6
8	110.9	146.0	1,236.6	2,719.9	18.6
9	115.0	128.5	1,236.l	2,702.4	21.0
10	128.6	126.3	1,236.0	2,702.4	21.4
11	132.8	135.7	1,235.7	2,693.6	19.8
12	148.8	141.4	1,235.8	2,696.5	19.1
13	152.9	125.2	1,236.3	2,711.l	21.7
14	156.1	129.6	1,235.7	2,693.6	20.8
15	160.5	133.8	1,235.7	2,693.6	20.1
16	162.6	137.2	1,235.l	2,676.2	19.5
17	171.1	162.4	1,234-l	2,647.4	16.3
18	172.0	159.8	1,233.4	2,627.3	16.4
19	173.2	169.6	1,232.5	2,601.7	15.3
20	176.4	157.7	1,232.l	2,590.4	16.4
21	174.2	150.2	1,231.8	2,582.0	17.2
22	169.7	163.9	1,231.2	2,565.1	15.7
23	178.5	188.8	1,231.2	2,565.1	13.6
24	188.5	150.3	1,230.7	2,551.l	17.0
25	199.0	172.5	1,230.7	2,551.l	14.8
26	197.0	168.3	1,230.9	2,556.7	15.2
27	194.4	168.4	1,231.2	2,565.1	15.2
28	199.3	178.7	1,231.4	2,570.7	14.4
29	195.2	175.9	1,231.6	2,576.3	14.6
30	191.9	191.2	1,230.9	2,556.7	13.4
Average	**153.0**	**147.7**	**1,235.l**	**2,679.l**	**18.6**

Table A.5 Daily midnight reservoir inflow, outflow, elevation, storage capacity, and water retention time for Lake Roosevelt in May, 1996. Data from CORPs daily summary reports.

		MAY			
Day of Month	**Reservoir Inflow (kcfs)**	**Reservoir Outflow (kcfs)**	**Reservoir Elevation (Ft)**	**Reservoir Storage (ksfd)**	**Water Retention Time (Days)**
1	184.1	186.0	1,230.3	2,540.0	13.7
2	187.2	164.7	1,230.4	2,542.7	15.4
3	180.9	182.7	1,229.7	2,523.3	13.8
4	187.2	196.7	1,228.7	2,495.8	12.7
5	184.8	180.0	1,228.3	2,484.8	13.8
6	173.6	175.2	1,228.0	2,476.6	14.1
7	171.4	180.7	1,227.6	2,465.8	13.6
8	163.8	164.5	1,227.6	2,465.8	15.0
9	165.1	156.0	1,227.8	2,471.2	15.8
10	156.8	160.7	1,227.5	2,463 .0	15.3
11	155.7	151.8	1,227.2	2,454.9	16.2
12	151.9	120.9	1,228.0	2,476.6	20.5
13	144.3	145.1	I,227.7	2,468.5	17.0
14	158.0	149.7	1,227.7	2,468.5	16.5
15	161.2	121.0	1,228.9	2,50 1.3	20.7
16	179.6	137.7	1,229.8	2,526.1	18.3
17	192.0	148.8	1,230.4	2,542.7	17.1
18	209.3	167.4	1,231.0	2,559.5	15.3
19	221.9	163.1	1,232.2	2,593.2	15.9
20	219.5	181.3	1,232.6	2,604.6	14.4
21	217.0	181.9	1,233.0	2,615.9	14.4
22	228.4	183.9	1,233.7	2,635.9	14.3
23	225.5	183.5	1,234.4	2,656.0	14.5
24	227.1	182.6	1,235.2	2,679.1	14.7
25	225.9	161.1	1,236.6	2,719.9	16.9
26	233.6	161.1	1,238.2	2,767.2	17.2
27	231.9	168.0	1,239.6	2,809.0	16.7
28	239.3	185.8	1,240.7	2,842.2	15.3
29	233.0	187.1	1,241.6	2,869.5	15.3
30	234.6	184.2	1,242.5	2,897.1	15.7
31	231.7	188.1	1,243.2	2,918.6	15.5
Average	**196.0**	**167.8**	**1,232.3**	**2,597.9**	**15.7**

Table A.6 Daily midnight reservoir inflow, outflow, elevation, storage capacity, and water retention time for Lake Roosevelt in June, 1996. Data from CORPs daily summary reports.

JUNE

Day of Month	Reservoir Inflow (kcfs)	Reservoir outflow (kcfs)	Reservoir Elevation (Ft)	Reservoir Storage (ksfd)	Water Retention Time (Days)
1	240.1	168.6	1,244.1	2,946.4	17.5
2	242.1	170.7	1,245.1	2,977.5	17.4
3	243.3	173.1	1,246.6	3,024.6	17.5
4	258.1	169.8	1,249.2	3,107.3	18.3
5	260.9	159.4	1,252.2	3,204.4	20.1
6	-259.5	155.1	1,255.0	3,296.9	21.3
7	252.2	155.2	1,257.2	3,370.8	21.7
8	267.0	163.3	1,259.0	3,432.0	21.0
9	283.5	169.4	1,261.2	3,507.8	20.7
10	278.5	177.5	1,263.5	3,588.0	20.2
11	277.6	176.1	1,265.8	3,669.2	20.8
12	262.9	186.1	1,267.0	3,708.4	19.9
13	266.9	188.4	1,267.9	3,744.2	19.9
14	263.6	189.4	1,268.9	3,780.2	20.0
15	257.1	182.0	1,269.8	3,812.1	20.9
16	251.4	179.6	1,270.5	3,838.1	21.4
17	254.4	164.9	1,271.6	3,878.3	23.5
18	262.9	183.7	1,273.1	3,933.4	21.4
19	251.4	188.8	1,274.1	3,970.4	21.0
20	243.3	182.9	1,275.1	4,007.6	21.9
21	226.1	176.7	1,276.0	4,041.3	22.9
22	214.4	160.2	1,277.1	4,082.6	25.5
23	210.1	160.2	1,278.1	4,120.5	25.7
24	213.5	176.7	1,279.0	4,154.6	23.5
25	220.0	182.0	1,279.7	4,181.4	23.0
26	212.5	191.1	1,280.1	4,196.7	22.0
27	216.0	183.7	1,280.8	4,223.6	23.0
28	203.1	180.3	1,280.9	4,223.6	23.4
29	202.3	154.1	1,281.6	4,254.5	27.6
30	202.3	144.8	1,282.6	4,293.5	29.7
Average	243.2	**173.1**	**1,267.8**	**3,752.3**	**21.8**

Table A.7 Daily midnight reservoir inflow, outflow, elevation, storage capacity, and water retention time for Lake Roosevelt in July, 1996. Data from CORPs daily summary reports.

JULY					
Day of Month	**Reservoir Inflow (kcfs)**	**Reservoir outflow (kcfs)**	**Reservoir Elevation (Ft)**	**Reservoir Storage (ksfd)**	**Water Retention Time (Days)**
1	199.1	153.1	1,283.6	4,332.7	28.3
2	191.8	156.0	1,284.4	4,364.4	28.0
3	195.1	148.5	1,285.3	4,400.2	29.6
4	184.7	142.2	1,285.8	4,420.2	31.1
5	200.4	144.6	1,286.6	4,452.4	30.8
6	193.5	161.0	1,287.0	4,468.6	27.8
7	199.2	153.8	1,287.8	4,501.l	29.3
8	201.5	171.2	1,288.5	4,529.7	26.5
9	185.6	176.0	1,288.4	4,525.6	25.7
10	203.1	178.1	1,288.8	4,542.0	25.5
11	200.6	190.4	1,288.9	4,546.2	23.9
12	186.2	185.5	1,288.4	4,525.6	24.4
13	197.3	198.0	1,288.0	4,509.3	22.8
14	181.8	169.0	1,288.0	4,509.3	26.7
15	182.3	176.6	1,288.0	4,505.2	25.5
16	178.7	141.4	1,288.7	4,537.9	32.1
17	185.8	147.9	1,289.3	4,562.6	30.8
18	172.5	172.7	1,289.2	4,558.5	26.4
19	175.8	168.5	1,289.2	4,558.5	27.1
20	166.7	142.6	1,289.3	4,562;6	32.0
21	180.2	158.4	1,289.6	4,575.0	28.9
22	176.0	171.3	1,289.7	4,579.2	26.7
23.	168.6	186.1	1,289.2	4,585.5	24.6
24	159.7	160.2	1,288.9	4,546.2	28.4
25	152.5	165.4	**1,288.3**	4,521.5	27.3
26	141.2	149.0	1,287.9	4,505.2	30.2
27	123.1	118.5	1,287.9	4,505.2	38.0
28	120.2	79.0	1,288.6	4,533.8	57.4
29	134.0	136.4	1,288.3	4,521.5	33.1
30	132.8	144.2	1,287.7	4,497.0	31.2
31	135.1	149.2	1,287.0	4,468.6	30.0
Average	**174.4**	**157.9**	**1,287.9**	**4,508.l**	**29.4**

Table A.8 Daily midnight reservoir inflow, outflow, elevation, storage capacity, and water retention time for Lake Roosevelt in August, 1996. Data from CORPs daily summary reports.

AUGUST					
Day of Month	Reservoir Inflow (kcfs)	Reservoir outflow (kcfs)	Reservoir Elevation (Ft)	Reservoir Storage (ksfd)	Water Retention Time (Days)
1	144.9	141.7	1,286.9	4,464.6	31.5
2	155.8	115.5	1,287.9	4,505.2	39.0
3	165.0	97.0	1,289.2	4,558.5	47.0
4	160.5	141.8	1,289.4	4,566.8	32.2
5	158.7	150.4	1,289.5	4,570.9	30.4
6	155.6	157.3	1,289.3	4,562.6	29.0
7	150.7	170.2	1,288.7	4,533.8.	26.6
8	138.1	160.1	1,287.9	4,505.2	28.1
9	135.4	146.4	1,287.3	4,480.8	30.6
10	125.1	110.7	1,287.4	4,484.8	40.5
11	125.4	133.8	1,286.8	4,460.5	33.3
12	127.4	152.2	1,286.l	4,432.3	29.1
13	133.4	148.1	1,285.5	4,408.2	29.8
14	140.3	164.0	1,284.8	4,380.3	26.7
15	135.2	152.0	1,284.3	4,360.4	28.7
16	133.8	126.4	1,284.3	4,360.4	34.5
17	143.4	123.3	1,284.4	4,364.4	35.4
18	119.0	123.5	1,283.9	4,344.6	35.2
19	131.0	145.3	1,283.4	4,324.8	29.8
20	i29.8	145.0	1,282.9	4,503.2	31.1
21	127.8	137.2	1,282.3	4,281.7	31.2
22	129.1	102.9	1,282.9	4,305.2	41.8
23	119.8	94.0	1,283.5	4,328.8	46.1
24	116.9	109.3	1,283.6	4,332.7	39.6
25	109.4	123.4	1,282.8	4,301.3	34.9
26	112.6	111.8	1,282.7	4,297.4	38.4
27	110.0	132.5	1,282.l	4,273.9	32.3
28	102.4	-120.8	1,281.5	4,250.6	35.2
29	100.4	123.7	1,280.8	4,223.6	34.1
30	95.4	113.6	1,280.2	4,196.7	36.9
31	102.6	92.0	1,280.3	4,204.3	45.7
Average	**130.2**	**131.2**	**1,284.9**	**4,392.5**	**34.3**

Table A.9 Daily midnight reservoir inflow, outflow, elevation, storage capacity, and water retention time for Lake Roosevelt in September, 1996. Data from CORPs daily summary reports.

SEPTEMBER					
Day of Month	**Reservoir Inflow (kcfs)**	**Reservoir outflow (kcfs)**	**Reservoir Elevation (Ft)**	**Reservoir Storage (ksfd)**	**Water Retention Time (Days)**
1	**88.9**	67.6	1,280.5	4,208.2	62.3
2	87.1	79.0	1,280.3	4,200.5	53.2
3	91.1	101.1	1,279.9	4,189.0	41.4
4	95.6	94.1	1,279.9	4,189.0	44.5
5	107.3	83.7	1,280.4	4,208.2	50.3
6	105.9	73.9	1,281.2	4,239.0	57.4
7	106.1	88.7	1,281.3	4,239.0	47.8
8	108.7	74.2	1,282.0	4,270.l	57.5
9	98.7	105.2	1,281.7	4,258.4	40.5
10	104.2	109.8	1,281.4	4,246.8	38.7
11	108.8	121.1	1,281.l	4,235.2	35.0
12	100.4	131.2	1,280.l	4,196.7	32.0
13	101.4	106.2	1,279.9	4,189.0	39.4
14	107.4	67.2	1,280.8	4,223.6	62.9
15	93.0	73.9	1,280.9	4,227.4	57.2
16	95.4	93.5	1,280.9	4,227.4	45.2
17	87.6	91.3	1,280.8	4,223.6	46.3
18	93.2	85.4	1,281.0	4,231.3	49.5
19	90.4	80.6	1,281.3	4,239.0	52.6 .
20	91.8	80.1	1,281.6	4,250.6	53.1
21	88.8	101.8	**1,280.9**	4,227.4	41.5
22	96.9	107.6	1,280.3	4,204.3	39.1
23	91.4	107.8	1,279.8	4,185.4	38.8
24	88.6	92.3	1,279.7	4,181.4	45.3
25	94.1	92.1	1,279.8	4,181.4	45.4
26	95.5	89.6	1,279.9	4,189.0	46.8
27	94.4	86.6	**280.l**	**4,196.7**	**48.5**
28	83.8	79.6	280.4	4,208.2	52.9
29	115.7	65.1	281.5	4,250.6	65.3
30	104.5	92.3	281.7	4.258.4	46.1
Average	**97.2**	**90.8**	**1,280.7**	**4,219.2**	**47.9**

Table A.10 Daily midnight reservoir inflow, outflow, elevation, storage capacity, and water retention time for Lake Roosevelt in October, 1996. Data from CORPs daily summary reports.

OCTOBER					
Day of Month	**Reservoir Inflow (kcfs)**	**Reservoir outflow (kcfs)**	**Reservoir Elevation (Ft)**	**Reservoir Storage (ksfd)**	Water **Retention Time (Days)**
1	i05.2	69.1	1,282.5	**4,289.5**	62.1
2	98.5	88.0	1,282.7	**4,297.4**	48.8
3	91.2	72.4	1,283.2	4,317.0	59.6
4	90.8	78.9	1,283.4	4,324.8	54.8
5	106.9	81.2	1,283.9	4,344.6	53.5
6	109.5	91.2	1,284.2	4,356.4.	47.8
7	114.3	105.1	1,284.3	4,360.4	41.5
8	113.8	103.4	1,284.5	4,368.3	42.2
9	101.6	94.4	1,284.6	4,372.3	46.3
10	105.5	97.5	1,284.8	4,380.3	44.9
11	97.4	98.4	1,284.8	4,380.3	44.5
12	95.3	77.8	1,285.0	4,388.2	56.4
13	91.3	75.8	1,285.2	4,396.2	58.0
14	90.7	103.7	1,284.8	4,380.3	42.2
15	96.0	96.0	1,284.8	4,380.3	45.6
16	85.5	97.4	1,284.5	4,368.3	44.8
17	90.4	120.1	1,283.8	4,340.6	36.1
18	89.5	93.4	1,283.7	4,336.7	46.4
19	90.8	75.2	1,284.0	4,348.5	57.8
20	97.2	80.7	1,284.2	4,356.4	54.0
21	93.4	116.0	1,283.6	4,332.7	57.4
22	93.6	101.5	1,283.4	4,324.8	42.6
23	98.2	106.0	1,283.2	4,317.0	40.7
24	95.3	95.3	1,283.2	4,3 17.0	45.3
25	88.9	84.9	1,283.3	4,320.9	50.9
26	86.5	67.8	1,283.8	4,340.6	64.0
27	99.6	61.1	1,284.6	4,372.3	71.6
28	111.6	105.2	1,284.7	4,376.6	41.6
29	97.5	85.5	1,285.0	4,388.2	51.3
30	95.6	99.5	1,284.9	4,384.2	44.1
31	80.8	88.8	1,284.7	4,376.3	4.9.3
Average	96.9	90.7	**1,284.l**	4,352.8	49.2

Table A.11 Daily midnight reservoir inflow, outflow elevation, storage capacity, and water retention time for Lake Roosevelt in November, 1996. Data from CORPs daily summary reports.

NOVEMBER					
Day of Month	**Reservoir Inflow (kcfs)**	**Reservoir Outflow (kcfs)**	**Reservoir Elevation (Ft)**	**Reservoir Storage (ksfd)**	**Water Retention Time (Days)**
1	84.1	104.0	1,284.2	4,356.4	41.9
2	86.2	74.3	1,284.5	4,368.3	58.8
3	92.0	52.1	1,285.5	4,368.3	83.8
4	96.8	100.8	1,285.4	4,364.4	43.3
5	88.7	112.7	1,284.8	4,380.3	38.9
6	86.1	102.1	1,284.4	4,364.4	42.7
7	89.1	105.0	1,284.0	4,348.5	41.4
8	90.4	86.4	1,284.1	4,352.5	50.4
9	91.9	83.6	1,284.3	4,360.4	52.2
10	93.7	70.6	1,284.8	4,380.3	62.0
11	89.9	90.7	1,284.7	4,376.3	48.3
12	83.9	91.1	1,284.5	4,368.3	48.0
13	84.6	98.5	1,284.2	4,356.4	44.2
14	86.5	96.4	1,283.9	4,344.6	45.1
15	90.7	98.6	1,283.7	4,336.7	44.0
16	91.4	95.4	1,283.6	4,332.7	45.4
17	87.0	69.2	1,284.1	4,352.5	62.9
18	106.1	116.0	1,283.8	4,340.6	37.4
19	105.4	109.3	1,283.7	4,336.7	39.7
20	112.4	92.7	1,284.2	4,356.4	47.0
21	114.6	112.6	1,284.3	4,360.4	38.7
22	105.3	119.2	1,283.9	4,344.6	36.4
23	90.5	104.3	1,283.6	4,332.7	41.5
24	82.7	72.8	1;283.8	4,340.6	59.6
25	95.9	95.9	1,283.8	4,340.6	45.3
26	94.8	106.7	1,283.5	4,328.8	40.6
27	99.9	95.4	1,283.6	4,332.7	45.4
28	99.1	55.8	1,284.6	4,372.3	78.4
29	113.6	89.9	1,285.0	4,388.2	48.8
30	107.8	114.3	1,284.8	4,380.3	38.3
Average	94.7	93.9	1,284.2	4,355.5	48.3

Table A.12 Daily midnight reservoir inflow, outflow elevation, storage capacity, and water retention time for Lake Roosevelt in December, 1996. Data from CORPs daily summary reports.

DECEMBER					
Day of Month	**Reservoir Inflow (kcfs)**	**Reservoir outflow (kcfs)**	**Reservoir Elevation (Ft)**	**Reservoir Storage (ksfd)**	**Water Retention Time (Days)**
1	101.1	117.0	1,284.4	4,364.4	37.3
2	104.4	128.2	1,283.8	4,340.6	33.9
3	102.0	133.5	1,283.0	4,309.l	32.3
4	100.2	139.2	1,282.0	4,270-l	30.7
5	88.1	121.1	1,281.2	4,239.0	35.0
6	. 98.6	108.3	1,280.9	4,227.4	39.0
7	100.8	109.8	1,280.7	1,280.7	11.7
8	102.1	87.0	1,280.9	4,227.4	48.6
9	116.0	114.6	1,280.9	4,227.4	36.9
10	100.8	102.7	1,280.9	4,227.4	41.2
11	110.1	92.7	1,281.3	4,242.9	45.8
12	102.4	86.9	1,281.7	4,258.4	49.0
13	97.2	91.4	1,281.9	4,266.2	46.7
14	89.2	94.7	1,281.7	4,258.4	45.0
15	97.2	93.4	1,281.8	4,262.3	45.6
16	96.6	119.9	1,281.2	4,239.0	35.4
17	103.5	149.8	1,280.0	4,23 1.3	28.2
18	108.1	146.2	1,279.0	4,154.6	28.4
19	107.6	141.8	1,278.l	4,120.5	29.1
20	103.7	126.4	1,277.5	4,097.7	32.4
21	94.0	115.8	1,276.9	4,075.l	35.2
22	87.6	125.3	1,275.7	4,030.l	32.2
23	83.8	117.8	1,274.8	3,995.5	33.9
24	94.0	118.2	1,274.l	3,970.4	33.6
25	81.8	107.7	1,273.4	3,944.5	36.6
26	89.5	142.9	1,272.0	3,892.9	27.2
27	78.3	113.0	1,271.0	3,856.3	34.1
28	99.1	71.7	1,271.8	3,882.0	54.1
29	100.7	82.3	1,272.3	3,904.0	47.4
30	104.1	70.4	1,273.2	3,937.l	55.9
31	103.4	61.7	1,274.2	3,974.1	83.6
Average	**98.3**	**110.7**	**1,278.5**	4,042.2	38.9

APPENDIX B

Corrected 1995 Zooplankton Length and Biomass Data

1996 Zooplankton Density, Length and Biomass Data

Table B.1 **Monthly and yearly mean zooplankton biomass values (mg/m^3) at Kettle Falls (Index Station l), in 1995.**

	May	Jul	Oct	Mean
Daphnia Spp.	**0.0**	<0.1	19.4	**6.5**
Leptodora kindtii	**0.0**	<0.1	0.0	**<0.1**
Total Cladocera	**0.0**	<0.1	19.4	**6.5**

Table B.2 **Monthly and yearly mean zooplankton biomass values (mg/m^3) at Gifford (Index Station 2), in 1995.**

	Jan	Feb	Apr	May	Jun	Jul	Aug	Sep	Oct	Mean
Daphnia Spp.	0.0	<0.l	<0.1	<0.1	<0.1	16.3	125.1	7.0	12.0	17.8
L. kindtii	0.0	0.0	0.0	<0.1	<0.1	0.3	3.1	0.0	0.4	0.4
Total Cladocera	0.0	<0.1	<0.1	<0.1	<0.1	16.6	128.2	7.0	12.4	18.2

Table B.3 **Monthly and yearly mean zooplankton biomass values (mg/m^3) at Hunters (Index Station 3), in 1995.**

	May	Jul	Oct	Mean
Daphnia Spp.	<0.1	8.8	27.3	12.0
Leptodora kindtii	0.0	1.8	0.0	0.6
Total Cladocera	<0. 1	10.6	27.3	12.6

Table B.4 **Monthly and yearly mean zooplankton biomass values (mg/m^3) at Porcupine Bay (Index Station 4), in 1995.**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Mean
Daphnia Spp.	0.3	1.9	0.0	<0.1	0.7	23.5	13.6	38.5	113.1	47.6	23.9
L. kindtii	0.0	0.0	0.0	0.0	0.0	1.9	1.4	0.0	0.0	<0.1	0.3,
Total Cladocera	**0.3**	1.9	0.0	<0.1	0.7	25.4	15.0	38.5	113.1	47.6	24.4

Table B.5 **Monthly and yearly mean zooplankton biomass values (mg/m^3) at the confluence of the Spokane River with the main-stream Columbia (Index Station Confluence), in 1995.**

	Jan	Feb	Mar	Apr	Jun	Aug	Sep	Mean
Daphnia Spp..	6.4	1.0	0.0	0.0	14.2	187.9	48.0	36.8
L. kindtii	0.0	0.0	0.0	0.0	2.7	7.4	0.2	1.5
Total Cladocera	6.4	1.0	0.0	0.0	16.9	195.3	48.2	38.3

Table B.6 **Monthly and yearly mean zooplankton biomass values (mg/m^3) at Seven Bays (Index Station 6), in 1995.**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Mean
Daphnia Spp.	2.7	0.2	<0.1	<0.1	0.6	18.8	17.8	36.8	104.7	0.5	18.2
L. kindtii	0.0	0.0	0.0	0.0	<0.1	2.8	3.3	0.5	0.1	0.0	0.7
Total Cladocera	2.7	0.2	<0.1	<0.1	0.6	21.6	21.1	37.3	104.8	0.5	18.9

Table B.7 **Monthly and yearly mean zooplankton biomass values (mg/m^3) at Keller (Index Station 7), in 1995.**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Mean
Daphnia Spp.	6.1	1.5	<0.1	<0.1	0.5	44.2	82.7	140.0	30.8	0.3	30.6
L. kindtii	0.0	0.0	0.0	0.0	0.0	0.7	1.0	0.8	0.3	0.0	0.3
Total Cladocera	6.1	1.5	<0.1	<0.1	0.5	44.9	83.7	140.8	31.1	0.3	30.9

Table B.8 **Monthly and yearly mean zooplankton biomass values (mg/m^3) at San Poil (Index Station S), in 1995.**

	Jul	Oct	Mean
Daphnia Spp.	77.1	9.0	43.1
Leptodora kindtii	1.9	0.0	1.0
Total Cladocera	79.0	9.0	44.0

Table B.9 Monthly and yearly mean zooplankton biomass values (mg/m^3) at Spring Canyon (Index Station 9), in 1995.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Mean
Daphnia Spp.	5.2	5.8	1.0	0.5	0.4	148.8	79.5	86.9	88.9	2.6	42.0
L. kindtii	0.0	0.0	0.0	0.0	<0.1	5.1	0.4	<0.1	<0.1	0.0	0.6
Total Cladocera	**5.2**	**5.8**	1.0	0.5	0.4	153.9	79.9	86.9	88.9	2.6	42.6

Table B.10 Monthly and yearly mean zooplankton biomass values (mg/m^3) at Rufus Woods (Index Station 10), in 1995.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Mean
Daphnia Spp.	12.9	4.8	0.3	0.2	0.3	28.5	18.3	23.4	11.3	0.4	**10.0**
L. kindtii	0.0	0.0	0.0	0.0	0.0	3.9	0.0	0.2	0.0	0.0	0.4
Total Cladocera	12.9	4.8	0.3	0.2	0.3	32.4	18.3	23.6	11.3	0.4	10.4

Table B.11 **Mean zooplankton lengths (mm) with standard deviations for select cladocera at Kettle Falls (Index Station l), in 1995.**

	Mav	Jul	Oct
D. g. mendota	- - + -	- + -	1.2 ± 0.4
D retrocurva	— ± —	1.2 ± 0.2	1.1 ± 0.4
D. pulex	— ± —	0.7 ± 0.4	1.4 ± 0.4
D. thorata	- - + -	- + -	— ± —
L. kindtii	— ± —	1.7 ± 0.6	— ± —
Daphnia Ave	**-- ± - -**	**0.8* 0.4**	**1.3 ± 0.4**

'—' Indicates no organisms present in samples

Table B.12 Mean zooplankton lengths (mm) with standard deviations for select cladocera at Gifford (Index Station 2), in 1995.

	Jan	Feb	Apr	May	Jun	Jul	Aug	Sep	Oct
D. g. mendota	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —	1.3 ± 0.4	— ± —	1.4 ± 0.4
D. retrocurva	— ± —	— ± —	— ± —	— ± —	— ± —	0.7 ± 0.2	1.1 ± 0.3	0.9 ± 0.4	1.0 ± 0.3
D. pulex	— ± —	1.3 ± 0.4	0.6 ± 0.2	1.0 ± 0.2	0.7 ± 0.4	0.9 ± 0.4	1.3 ± 0.4	1.1 ± 0.4	1.3 ± 0.4
D. thorata	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —
L. kindtii	— ± —	— ± —	— ± —	1.0 ± 0.2	4.8 ± 4.1	4.5 ± 2.5	5.5 ± 1.6	— ± —	10. ± —
Daphnia Ave	-- ± --	1.3 ± 0.4	0.6 ± 0.2	1.0 ± 0.2	0.7 ± 0.4	0.9 ± 0.4	1.2 ± 0.4	1.0 ± 0.4	1.2 ± 0.4

'—' Indicates no organisms present in samples

Table B.13 Mean zooplankton lengths (mm) with standard deviations for select cladocera at Hunters (Index Station 3), in 1995.

	May	Jul	Oct
D. g. mendota	— ± —	1.2 ± 0.4	1.3 ± 0.4
D. retrocurva	— ± —	0.9 ± 0.2	1.1 ± 0.4
D. pulex	0.7 ± 0.3	1.4 ± 0.5	1.4 ± 0.5
D. thorata	— ± —	— ± —	— ± —
L. kindtii	— ± —	6.0 ± 1.9	— ± —
Daphnia Ave	**0.7 ± 0.3**	**1.2 ± 0.4**	**1.3 ± 0.4**

'—' Indicates no organisms present in samples

Table B.14 Mean zooplankton lengths (mm) with standard deviations for select cladocera at Porcupine Bay (Index Station 4), in 1995.

	Jan	Feb	Apr	May	Jun	Jul	Aug	Sep	Oct
D. g. mendota	— ± —	— ± —	— ± —	— ± —	1.9 ± 0.6	1.9 ± 0.5	— ± —	— ± —	— ± —
D. retrocurva	— ± —	— ± —	— ± —	— ± —	0.9 ± 0.7	0.7 ± 0.3	1.1 ± 0.5	— ± —	— ± —
D. pulex	1.2 ± 0.5	1.8 ± 0.6	0.8 ± —	1.4 ± 0.4	1.4 ± 0.7	0.8 ± 0.5	1.7 ± 0.6	1.7 ± 0.4	1.4 ± 0.5
D. thorata	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —
L. kindtii	— ± —	— ± —	— ± —	— ± —	4.7 ± 1.9	6.4 ± 3.1	— ± —	— ± —	3.0 ± —
Daphnia Ave	**1.2 ± 0.5**	**1.8 ± 0.6**	**0.8 ± --**	**1.4 ± 0.4**	**1.2 ± 0.6**	**0.8 ± 0.5**	**1.4 ± 0.6**	**1.7 ± 0.4**	**1.4 ± 0.5**

'—' Indicates no organisms present in samples

Table B.15 Mean zooplankton lengths (mm) with standard deviations for select cladocera at the confluence of the Spokane River with the main-stream Columbia (Index Station Confluence), in 1995.

	Jan	Feb	Mar	Apr	Jun	Aug	Sep
D. g. mendota	— ± —	— ± —	— ± —	— ± —	0.8 ± 0.3	— ± —	— ± —
D. retrocurva	— ± —	— ± —	— ± —	— ± —	1.1 ± 0.5	1.0 ± 0.4	1.0 ± 0.3
D. pulex	1.2 ± 0.5	1.1 ± 0.5	— ± —	— ± —	1.2 ± 0.5	1.7 ± 0.6	1.6 ± 0.5
D. thorata	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —
L. kindtii	— ± —	— ± —	— ± —	— ± —	5.3 ± 3.3	7.6 ± 2.9	6.0 ± 1.4
Daphnia Ave	**1.2 ± 0.5**	**1.1 ± 0.5**	-- ± --	-- ± --	**1.1 ± 0.5**	**1.3 ± 0.6**	**1.3 ± 0.5**

'—' Indicates no organisms present in samples

Table B.16 Mean zooplankton lengths in (mm) with standard deviations for select cladocera at Seven Bays (Index Station 6), in 1995.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
D. g.mendota	— ± —	— ± —	— ± —	— ± —	— ± —	0.7 ± 0.2	1.0 ± 0.3	1.2 ± 0.4	— ± —	— ± —
D. retrocurva	— ± —	— ± —	— ± —	— ± —	0.6 ± 0.2	1.1 ± 0.4	0.9 ± 0.3	1.1 ± 0.4	— ± —	— ± —
D. pulex	1.5 ± 0.5	1.1 ± 0.5	1.0 ± 0.2	1.2 ± 0.2	0.8 ± 0.4	1.3 ± 0.5	1.0 ± 0.4	1.2 ± 0.5	1.5 ± 0.4	1.5 ± 0.4
D. thorata	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —
L. kindtii	— ± —	— ± —	— ± —	— ± —	— ± —	5.2 ± 2.8	6.1 ± 2.4	6.4 ± 3.1	4.5 ± 0.8	— ± —
Daphnia Ave	**1.5 ± 0.5**	**1.1 ± 0.5**	**1.0 ± 0.2**	**1.2 ± 0.2**	**0.8 ± 0.3**	**1.1 ± 0.5**	**1.0 ± 0.3**	**1.3 ± 0.5**	**1.5 ± 0.4**	**1.5 ± 0.4**

'—' Indicates no organisms present in samples

Table B.17 Mean zooplankton lengths (mm) with standard deviations for select cladocera at Keller Ferry (Index Station 7), in 1995.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
D. g.mendota	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —	1.5 ± 0.2	1.6 ± 0.4	— ± —	— ± —
D. retrocurva	— ± —	— ± —	— ± —	— ± —	— ± —	1.2 ± 0.4	1.1 ± 0.3	1.3 ± 0.3	0.8 ± 0.2	— ± —
D. pulex	1.3 ± 0.5	1.6 ± 0.6	1.4 ± 0.3	1.0 ± 0.4	0.9 ± 0.4	1.0 ± 0.4	1.3 ± 0.5	1.7 ± 0.4	1.5 ± 0.4	1.0 ± 0.3
D. thorata	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —
L. kindtii	— ± —	— ± —	— ± —	— ± —	— ± —	3.8 ± 2.1	4.8 ± 1.8	5.4 ± 1.1	8.0 ± 0.0	— ± —
Daphnia Ave	1.3 ± 0.5	1.6 ± 0.6	1.4 ± 0.3	1.0 ± 0.4	0.9 ± 0.4	1.0 ± 0.4	1.2 ± 0.5	1.5 ± 0.4	1.5 ± 0.4	1.0 ± 0.3

'—' Indicates no organisms present in samples

Table B.18 Mean zooplankton lengths (mm) with standard deviations for select cladocera at San Poil (Index Station 8), in 1995.

	Jul	Oct
D. g. mendota	- - *f* -	- * -
D. retrocurva	0.6 ± 0.2	— ± —
D. pulex	1.2 ± *0.5*	1.2 ± 0.4
D. thorata	- - *f* -	- * -
L. kindtii	6.8 ± 3.0	— ± —
Daphnia Ave	**1.1 ± 0.5**	**1.2 ± 0.4**

'—' Indicates no organisms present in samples

Table B.19 Mean zooplankton lengths (mm) with standard deviations for select cladocera at Spring Canyon (Index Station 9), in 1995.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
D. g. mendota	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —	1.0 ± 0.1	1.5 ± 0.4	1.1 ± 0.1	— ± —
D. retrocurva	— ± —	— ± —	— ± —	— ± —	— ± —	1.2 ± 0.4	1.0 ± 0.3	1.1 ± 0.2	1.0 ± 0.2	— ± —
D. pulex	1.4 ± 0.5	1.6 ± 0.6	1.8 ± 0.4	0.9 ± 0.3	0.9 ± 0.3	1.6 ± 0.5	1.3 ± 0.4	1.5 ± 0.5	1.6 ± 0.5	1.2 ± 0.5
D. thorata	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —	2.0 ± 0.6	— ± —	— ± —
L. kindtii	— ± —	— ± —	— ± —	— ± —	2.3 ± 0.5	7.0 ± 3.1	4.4 ± 1.9	3.0 ± —	4.0 ± 0.0	— ± —
Daphnia Ave	1.4 ± 0.5	1.6 ± 0.6	1.8 ± 0.4	0.9 ± 0.3	0.9 ± 0.3	1.4 ± 0.5	1.2 ± 0.4	1.4 ± 0.5	1.5 ± 0.5	1.2 ± 0.5

'—' Indicates no organisms present in samples

Table B.20 Mean zooplankton lengths (mm) with standard deviations for select cladocera at Rufus Woods (Index Station 10), in 1995.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
D. g. mendota	- - -	- - -	— ± —	— ± —	— ± —	— ± —	— ± —	2.3 ± —	- - -	- - -
D. retrocurva	— ± —	— ± —	— ± —	— ± —	— ± —	*0.9 ± 0.4*	*0.9 ± 0.3*	1.6 ± 0.4	— ± —	— ± —
D. pulex	1.7 ± 0.5	1.4 ± 0.5	1.0 ± 0.2	1.1 ± 0.6	1.1 ± 0.5	1.5 ± 0.5	1.3 ± 0.6	1.6 ± 0.4	1.5 ± 0.4	0.9 ± 0.3
D. thorata	— ± —	- - -	- - -	— ± —	— ± —	— ± —	- - -	0.4 ± 0.0	— ± —	— ± —
L. kindtii	— ± —	— ± —	— ± —	— ± —	— ± —	7.4 ± 2.6	6.4 ± 3.1	10.0 ± —	— ± —	— ± —
Daphnia Ave	1.7 ± 0.5	1.4 ± 0.5	1.0 ± 0.2	1.1 ± 0.6	1.1 ± 0.5	1.2 ± 0.7	1.2 ± 0.6	1.6 ± 0.4	1.5 ± 0.4	0.9 ± 0.3

'—' Indicates no organisms present in samples

Table B.21 Mean density (#/m^3) values for zooplankton samples collected in March, 1996 at three sampling locations on Lake Roosevelt.

	Gifford Mean Density (#/m^3)	Porcupine Bay Mean Density (#/m^3)	Seven Bays Mean Density (#/m^3)	Spring Canyon Mean Density (#/m^3)
Cladocera				
Ceriodaphnia quadranqula				
Daphnia galeata mendotae				0.2
Daphnia retrocurva				
Daphnia thorata				
Daphnia pulex				
Megafenestra aurita				
Simocephalus serrulatus				
Alona guttata				
Alona quadrangularis				
Chydorus sphaericus				
Eurycerus lamellatus				
Pleuroxus denticulatus				
Diaphanosoma brachyurum				0.5
Diaphanosoma birgei				
Sida crystallina				
Macrothrix laticornis				
Streblocerus serricaudatus				
Bosmina longirostris	0.5	3.8	1.1	0.5
Leptodora kindtii				
Eucopepoda				
Leptodiaptomus ashlandi	6.3	1.3	11.6	18.7
Skistodiaptomus oregonensis				
Epischura nevadensis		0.4		
Diacyclops bicuspidatus thomasi	33.8	139.9	132.8	117.8
Mesocyclop edax				
Bryocamptus spp.				
Nauplii	1.2	2.9	5.9	9.7
Total *Daphnia* spp.	0.0	0.0	0.0	0.2
Total Cladocera	0.5	3.8	1.1	1.2
Total Copepoda	40.1	141.5	144.4	136.5
Total Nauplii	1.2	2.9	5.9	9.7
Grand Total	41.8	148.2	151.4	147.4

Table B.22 Mean density (#/m^3) values for zooplankton samples collected in April, 1996 at four sampling locations on Lake Roosevelt.

	Gifford Mean Density (#/m^3)	Porcupine Bay Mean Density (#/m^3)	Seven Bays Mean Density (#/m^3)	Spring Canyon Mean Density (#/m^3)
Cladocera				
Cerialaphnia quadranqula				
Daphnia galeata mendotae				
Daphnia retrocurva			0.1	
Daphnia pulex	0.3	5.9	3.1	5.1
Daphnia thorata				
Megafenestra aurita				
Simocephalus serrulatus				
Alona guttata				
Alona quadrangularis				
Chydorus sphaericus				
Eurycerus lamellatus				
Pleuroxus denticulatus				
Diaphanosoma brachyurum			0.1	0.2
Diaphanosoma birgei				
sida crystallina				
Macrothrix laticornis				
Streblocerus serricaudatus				
Bosmina longirostris	0.2	2.5	1.2	1.4
Leptodora kindtii				
Eucopepoda				
Leptodiaptomus ashlandi		2.3	16.6	18.1
Skistodiaptomus oregonensis				
Epischura nevadensis				0.7
Diacyclops bicuspidatus thomasi	4.3	118.4	119.3	224.8
Mesocyclop edax				
Bryocamptus spp.				
Nauplii	0.5	27.1	14.1	28.1
Total *Daphnia* spp.	**0.3**	**5.9**	**3.1**	**5.1**
Total Cladocera	**0.5**	**8.4**	**4.4**	**6.7**
Total Copepoda	**4.3**	12b.7	**135.9**	**243.6**
Total Nauplii	**0.5**	27.1	**14.1**	**28.1**
Grand Total	5.3	156.2	154.4	278.4

Table B.23 Mean density (#/m^3) values for zooplankton samples collected in May, 1996 at four sampling locations on Lake Roosevelt.

	Gifford Mean Density (#/m^3)	Porcupine Bay Mean Density (#/m^3)	Seven Bays Mean Density (#/m^3)	Spring. Canyon Mean Density (#/m^3)
Cladocera				
Ceriodaphnia quadranqula				
Daphnia galeata mendotae			*0.9*	
Daphnia retrocurva				
Daphnia pulex	0.7	1.4	4.2	10.4
Daphnia thorata				
Megafenstra aurita				
Simocephalus serrulatus				
Alona guttata				
Alona quadrangularis				
Chydorus sphaericus				
Eurycerus lamellatus				
Pleuroxus denticulutus				
Diaphanosoma brachyurum			2.0	0.7
Diaphanosoma birgei				
Sida crystallina				
Macrothtix laticornis				
Streblocerus serricaudatus				
Bosmina longirostris	0.3		54.2	4.3
Leptodora kindtii			2.8	13.0
Eucopepoda				
Leptodiaptomus ashlandi	*20.9*	4.0	21.8	51.4
Skistodiaptomus oregonensis				
Epischura nevadensis		0.3		13.9
Diacyclops bicuspidatus thomasi	52.8	86.1	506.4	638.6
Mesocyclop edax				0.1
Bryocamptus spp.				
Nauplii	4.7	10.1	114.6	237.8
			5.1	
Total *Daphnia* spp.	**0.7**	**1.4**	**64.0**	**10.4**
Total Cladocera	**1.0**	**1.4**	[illegible]	**28.4**
Total Copepoda	**73.7**	**90.5**	**528.2**	**704.0**
Total Nauplii	**4.7**			
Grand Total	**79.4**	101.9 10.1	706.8 114.6	237.8 970.1

Table B-24 Mean density (#/m^3) values for zooplankton samples collected in June, 1996 at four sampling locations on Lake Roosevelt.

	Gifford Mean Density (#/m^3)	Porcupine Bay Mean Density (#/m^3)	Seven Bays Mean Density (#/m^3)	Spring Canyon Mean Density (#/m^3)
Cladocera				
Ceriodaphnia quadranqula				
Daphnia galeata mendotae				
Daphnia retrocurva		180.3	179.8	92.9
Daphnia pulex	0.5	40.5	180.8	189.5
Daphnia thorata				
Megafenestra aurita				
Simocephalus serrulatus				
Alona guttata				
Alona quadrangularis				
Chydorus sphaericus				
Eurycerus lamellatus				
Pleuroxus denticulatus				
Diaphanosomu brachyunun		1.8		
Diaphanosomu birgei				
Sida crystallina				
Macrothrix laticomis				
Streblocerus serricaudatus				
Bosmina longirostris	1.8		33.1	83.7
Leptodora kindtii		1.8	1.4	2.8
Eucopepoda				
Leptodiaptomus ashlandi	7.1	358.7	135.7	98.4
Skistodiaptomus oregonensis				
Epischura nevadensis	0.7	147.2	26.2	15.6
Diacyclops bicuspidatus thomasi	181.1	6,269.7	3,063.l	4,595.1
Mesocyclop edax		25.8		59.3
Bryocamptus spp.				
Nauplii	15.1	143.5	149.5	52.4
Total *Daphnia* spp.	**0.5**	**220.8**	**360.6**	**282.4**
Total Cladocera	**2.3**	**224.4**	**395.1**	**368.9**
Total Copepoda	**188.9**	**6,801.4**	**3,225.0**	**4,768.5**
Total Nauplii	**15.1**	**143.5**	**149.5**	**52.4**
Grand Total	**206.3**	**7,169.3**	**3,769.6**	**5,189.8**

Table B.25 Mean density (#/m³) values for zooplankton samples collected in July, 1996 at four sampling locations on Lake Roosevelt.

	Gifford Mean Density (#/m³)	Porcupine Bay Mean Density (#/m³)	Seven Bays Mean Density (#/m³)	Spring Canyon Mean Density (#/m³)
Cladocera				
Ceriodaphnia quudranqula				
Daphnia galeata mendotae		1.8		
Daphnia retrocurva	11.0	509.6	592.4	1,333.8
Daphnia pulex	7.4	3,035.5	1,302.5	2,323.6
Daphnia thorata				
Megafenestra aurita				
Simocephalus serrulutus				
Alona guttata				
Alona quadrangularis				
Chydorus sphaericus				
Eurycerus lamellatus				
Pleuroxus denticulatus				
Diaphanosoma brachyurum		99.3	23.9	11.0
Diaphanosoma birgei				
Sida crystallina				
Macrothrix laticomis				
Streblocerus serricaudatus				
Bosima longirostris	185.8	7.4	1.8	
Leptodora kindtii		123.3	99.3	60.7
Eucopepoda				
Leptodiaptomus ashlandi	46.0	726.7	616.3	849.9
Skistodiaptomus oregonensis				
Epischura nevadensis		248.4	42.3	66.2
Diacyclops bicuspidatus thomasi	1,113.0	5,064.7	5,554.1	3,593.0
Mesocyclop edax				
Bryocamptus spp.				
Nauplii	515.1	42.3	1.8	18.4
Total *Daphnia* spp.	18.4	3,547.0	1,894.9	3,657.3
Total Cladocera	204.2	3,776.9	2,020.0	3,729.1
Total Copepoda	1,159.0	6,039.8	6,212.7	4,509.1
Total Nauplii	515.1	42.3	1.8	18.4
Grand Total	1,878.3	9,859.0	8,234.5	8,256.6

Table B.26 Mean density (#/m^3) values for zooplankton samples collected in August, 1996 at four sampling locations on Lake Roosevelt.

	Gifford Mean Density (#/m^3)	Porcupine Bay Mean Density (#/m^3)	Seven Bays Mean Density (#/m^3)	Spring Canyon Mean Density (#/m^3)
Cladocera				
Ceriodaphnia quadranqula				
Daphnia galeata mendotae			27.6	
Daphnia retrocurva	156.4		276.0	311.4
Daphnia pulex	53.4	1,569.3	1,090.0	2,454.2
Daphnia thorata				
Megafenestra aurita				
Simocephalus serrulatus				
Alona guttata				
Alona quadrangularis				
Chydorus sphaericus				
Eurycerus lamellutus				
Pleuroxus denticulatus				
Diaphanosoma brachyunrm		*12.9*	4.6	5.5
Diaphanosoma birgei				
Sida crystallina				
Macrothrix laticornis				
Streblocerus serricaudatus				
Bosmina longirostris			9.2	2.8
Leptodora kindtii			13.8	27.1
Eucopepoda				
Leptodiaptomus ashlandi	44.2	1,400.0	458.1	1,452.0
Skistodiaptomus oregonensis				
Epischura nevadensis		44.2	12.9	50.1
Diacyclops bicuspidatus thomasi	401.1	1,538.0	2,312.5	3,903.4
Mesocyclop edax				
Bryocamp tus spp.				
Nauplii	64.4	18.4	34.0	34.5
Total *Daphnia* spp.	**209.7**	**1,569.3**	**1,393.6**	**2,765.5**
Total Cladocera	**209.7**	**1,582.2**	**1,421.2**	**2,801.0**
Total Copepoda	**445.2**	**2,982.2**	**2,783.5**	**5,405.5**
Total Nauplii	**64.4**	**18.4**	34.0	34.5
Grand Total	**719.3**	**4,582.8**	**4,238.7**	**8,241.0**

Table B.27 Mean density ($\#/m^3$) values for zooplankton samples collected in September, 1996 at four sampling locations on Lake Roosevelt.

	Gifford Mean Density ($\#/m^3$)	Porcupine Bay Mean Density ($\#/m^3$)	Seven Bays Mean Density ($\#/m^3$)	Spring Canyon Mean Density ($\#/m^3$)
Cladocera				
Ceriodaphnia quadranqula				
Daphnia galeata mendotae			36.8	69.9
Daphnia retrocurva	114.1	25.8	631.0	121.4
Daphniapulex	1,501.2	360.6	1,876.5	2,294.1
Daphnia thorata				
Megafenestra aurita				
Simocephalus serrulatus				
Alona Guttata				
Alona quadrangularis				
Chydorus sphaericus				
Eurycerus lamellatus				
Pleuroxus denticulatus				
Diaphanosoma brachyurum	*23.9*	33.1	88.3	
Diaphanosoma birgei				
Sida crystallina				
Macrothrix laticomis				
Streblocerus serricaudutus				
Bosmina longirostris			44.2	7.4
Leptodora kindtii	1.8	3.7		27.6
Eucopepoda				
Leptodiaptomus ashlandi	577.7	1,602.4	1,722.0	2,925.1
Skistodiaptomus oregonensis				
Epischura nevadensis			20.2	44.2
Diacyclops bicuspidatus thomasi	*402.9*	550.1	1,339.3	2,719.l
Mesocyclop edax				1.8
Bryocamptus spp.				
Nauplii	22.1	14.7	99.3	40.5
Total *Daphnia* spp.	**1,615.3**	**386.3**	**2,544.3**	**2,485.4**
Total Cladocera	**1,641.0**	**423.1**	**2,676.S**	**2,520.4**
Total Copepoda	**980.6**	**2,152.5**	**3,081.5**	**5,690.2**
Total Nauplii	**22.1**	**14.7**	**99.3**	**40.5**
Grand Total	**2,643.7**	**2,590.3**	**5,857.6**	**8,251.l**

Table B.28 Mean density (#/m³) values for zooplankton samples collected in October, 1996 at three sampling locations on Lake Roosevelt.

	Gifford Mean Density (#/m³)	Porcupine Bay Mean Density (#/m³)	Spring Canyon Mean Density (#/m³)
Cladocera			
Ceriodaphnia quadranqula			
Daphnia galeata mendotae			
Daphnia retrocurva	42.3	9.2	
Daphnia pulex	772.7	5,353.5	390.0
Daphnia thorata			
Megafenestra aurita			
Simocephalus serrulatus			
Alona guttata			
Alona quadrangularis			
Chydorus sphaericus			
Eurycerus lamellatus			
Pleuroxus denticulatus			
Diaphanosoma brachyunun	5.5	99.3	1.8
Diaphanosoma birgei			
Sida crystallina			
Macrothrix laticomis			
Streblocerus serricaudatus			
Bosmina longirostris	505.9		29.4
Leptodora kindtii		1.8	
Eucopepoda			
Leptodiaptomus ashlandi	7.4	721.2	2,259.2
Skistodiaptomus oregonensis			
Epischura nevadensis		7.4	14.7
Diacyclops bicuspidatus thomasi	44.2	2,327.2	599.7
Mesocyclop edax			
Bryocamptus spp.			
Nauplii	22.1	14.7	95.7
Total Daphnia spp.	815.0	5,362.7	390.0
Total Cladocera	1,326.4	5,463.9	421.3
Total Copepoda	51.5	3,055.8	2,873.6
Total Nauplii	22.1	14.7	95.7
Grand Total	1,400.0	8,534.4	3,390.6

Table B.29 Mean density (#/m^3) values for zooplankton samples collected in November, 1996 at four sampling locations on Lake Roosevelt.

	Gifford Mean Density (#/m^3)	Porcupine Bay Mean Density (#/m^3)	Seven Bays Mean Density (#/m^3)	Spring Canyon Mean Density (#/m^3)
Cladocera				
Ceriodaphnia quadranqula				
Daphnia galeata mendotae				
Daphnia retrocurva				
Daphnia pulex	12.6	**833.4**	**2,194.8**	**90.2**
Daphnia thorata				
Megafenstra aurita				
Simocephalus serrulatus				
Alona guttata				
Alona quadrangularis				
Chydorus sphaericus				
Eurycerus lamellatus				
Pleuroxus denticulatus				
Diaphanosoma brachyurum	**0.2**	1.8		
Diaphanosoma birgei				
Sida crystallina				
Macrothrix laticomis				
Streblocerus serricaudatus				
Bosmina longirostris			**35.0**	**38.6**
Leptodora kindtii				
Eucopepoda				
Leptodiaptomus ashlandi	1.0	**347.7**	**86.5**	**325.6**
Skistodiaptomus oregonensis				
Epischura nevadensis			**7.4**	
Diacyclops bicuspidatus thomasi	10.1	505.9	261.2	**645.7**
Mesocyclop edax				
Bryocamptus spp.				
Nauplii	**0.5**	**29.4**		**69.9**
Total *Daphnia* spp.	**12.6**	**833.4**	**2,194.8**	**90.2**
Total Cladocera	**12.8**	**835.2**	**2,229.7**	**128.8**
Total Copepoda	**11.1**	**853.6**	**355.1**	**971.4**
Total Nauplii	**0.5**	**29.4**	**0.0**	**69.9**
Grand Total	**24.4**	**1,718.2**	**2,584.8**	**1,170.l**

Table B.30 Mean density (#/m^3) values for zooplankton samples collected in December, 1996 at four sampling locations on Lake Roosevelt.

	Gifford Mean Density (#/m^3)	Porcupine Bay Mean Density (#/m^3)	Seven Bays Mean Density (#/m^3)	Spring Canyon Mean Density (#/m^3)
Cladocera				
Ceriodaphnia quadranqula				
Daphnia galeata mendotae				
Daphnia retrocurva				
Daphnia pulex	3.0	2,220.5	93.6	2,798.2
Daphnia thorata				
Megafenestra aurita				
Simocephalus serrulatus				
Alona guttata				
Alona quadrangularis				
Chydorus sphaericus				
Eurycerus lamellatus				
. *Pleuroxus denticulatus*				
Diaphanosoma brachyurum				
Diaphanosoma birgei				
Sida crystallina				
Macrothrix laticomis				
Streblocerus serricaudatus				
Bosmina longirostris				49.7
Leptodora kindtii				
Eucopepoda				
Leptodiaptomus ashlandi	3.5	870.2	47.4	1,026.6
Skistodiaptomus oregonensis				
Epischura nevadensis			0.2	9.2
Diacyclops bicuspidatus thomasi	3.6	517.0	58.0	1,330.l
Mesocyclop edax				
Bryocamptus spp.				
Nauplii	0.2	75.4	11.4	16.6
Total *Daphnia* spp.	**3.0**	**2,220.5**	**93.6**	**2,798.2**
Total Cladocera	**3.0**	**2,220.5**	**93.6**	**2,847.9**
Total Copepoda	**7.1**	**1,387.1**	**105.5**	**2,365.9**
Total Nauplii	**0.2**	**75.4**	**11.4**	**16.6**
Grand Total	**10.3**	**3,683.0**	**210.4**	**5,230.3**

Table B.31 Representative zooplankton size ranges (mm), mean lengths (mm) and biomass values (mg/m^3) for samples collected at four locations in March, 1996 on Lake Roosevelt.

	Size range (mm)	Mean length (mm)	Biomass (mg/m^3)
Location 2 Gifford			
Daphnia galeata mendotae	--	--	*0.00*
Daphnia retrocurva	--	--	*0.00*
Daphnia pulex	--	--	*0.00*
Daphnia thorata	--	--	*0.00*
Leptodora kindtii	--	--	*0.00*
Total Loc 2 Biomass			**0.00**
Location 4 Porcupine Bay			
Daphnia galeata mendotae	--	--	*0.00*
Daphnia retrocurva	--	--	*0.00*
Daphnia pulex	--	--	*0.00*
Daphniu thorata	--	--	*0.00*
Leptodora kindtii	--	--	*0.00*
Total Loc 4 Biomass			**0.00**
Location 6 Seven Bays			
Daphniu galeata mendotae	--	--	*0.00*
Daphnia retrocurva	--	--	*0.00*
Daphnia pulex	--	--	*0.00*
Daphnia thorata	--	--	*0.00*
Leptodora kindtii	--	--	*0.00*
Total Loc 6 Biomass			**0.00**
Location 9 Spring Canyon			
Daphniu galeata mendotae	--	--	*0.00*
Daphniu retrocurva			*0.00*
Daphnia pulex	1.00-1.10	1.1	<0.01
Daphniu thorata	--	--	*0.00*
Leptodora kindtii	--	--	*0.00*
Total Loc 9 Biomass			**<0.01**

Table B.32 Representative zooplankton size ranges (mm), mean lengths (mm) and biomass values (mg/m^3) for samples collected at four locations in April, 1996 on Lake Roosevelt.

	Size range (mm)	Mean length (mm)	Biomass (mg/m^3)
Location 2 Gifford			
Daphnia galeata mendotae	--	--	*0.00*
Daphnia retrocurva			*0.00*
Daphnia pulex	**0.40-0.50**	**0.5**	<0.01
Daphnia thorata	--	--	*0.00*
Leprodora kindtii	--	--	*0.00*
Total Loc 2 Biomass			**<0.01**
Location 4 Porcupine Bay			
Daphnia galeata mendotae	--	--	*0.00*
Daphnia retrocurva			*0.00*
Daphnia pulex	0.40-l .20	0.8	**0.03**
Daphnia thorata	--	--	*0.00*
Leptodora kindtii	--	--	*0.00*
Total Loc 4 Biomass			**0.03**
Location 6 Seven Bays			
Daphnia galeata mendotae	--	--	*0.00*
Daphnia retrocurva		0.50	<0.01
Daphnia pulex	0.50-1.30	0.8	0.01
Daphnia thorata	--	--	*0.00*
Leptodora kindtii	--	--	*0.00*
Total Loc 6 Biomass			**0.01**
Location 9 Spring Canyon			
Daphnia galeata mendotae	--	--	*0.00*
Daphnia retrocurva			*0.00*
Daphnia pulex	0.50-1.60	0.9	0.04
Daphnia thorata	--	--	*0.00*
Leptodora kindtii	--	--	*0.00*
Total Loc 9 Biomass			0.04

Table B.33 Representative zooplankton size ranges (mm), mean lengths (mm) and biomass values (mg/m³) for samples collected at four locations in May, 1996 on Lake Roosevelt.

	Size range (mm)	Mean length (mm)	Biomass (mg/m³)
Location 2 Gifford			
Daphnia galeata mendotae	--	--	0.00
Daphnia retrocurva		0.7	0.00
Daphnia pulex	0.70-0.70		<0.01
Daphniu thorata	--	--	0.00
Leptodara kindtii	--	--	0.00
Total Loc 2 Biomass			**<0.01**
Location 4 Porcupine Bay			
Daphniu galeata mendotae		--	*0.00*
Daphniu retrocurva	0.50-1.10	0.8	<0.01
Daphnia thorata	--	--	0.00
Leptodora kindtii	--	--	0.00
Total Loc 4 Biomass			**<0.01**
Location 6 Seven Bays			
Daphnia galeata mendotae	--	--	*0.00*
Daphniu retrocurva		--	*0.00*
Daphnia pulex	0.50-1.50	1.0	0.03
Daphniu thorata	--	--	*0.00*
Leptodora kindtii	2.00-4.00	3.0	0.02
Total Loc 6 Biomass			0.05
Location 9 Spring Canyon			
Daphnia galeata mendotae	--	--	*0.00*
Daphniu retrocurva			*0.00*
Daphnia pulex	0.40-1.70	1.0	0.09
Daphnia thorata		--	*0.00*
Leptodora kindtii	1.00-5.00	2.9	0.08
Total Loc 9 Biomass			**0.17**

Table B.34 Representative zooplankton size ranges (mm), mean lengths (mm) and biomass values (mg/m^3) for samples collected at four locations in June, 1996 on Lake Roosevelt.

	Size range (mm)	Mean length (mm)	Biomass (mg/m^3)
Location 2 Gifford			
Daphnia galeata mendotae	--	--	*0.00*
Daphnia retrocurva	--	--	*0.00*
Daphnia pulex	0.60-1.00	0.8	<0.01
Daphnia thorata			0.00
Leptodora kindtii	--	--	0.00
Total Loc 2 Biomass			**<0.01**
Location 4 Porcupine Bay			
Daphnia galeata mendotae			*0.00*
Daphnia retrocurva	0.30-1.40	0.9	0.48
Daphnia pulex	0.30-1.40	1.0	0.37
Daphnia thorata	--	--	0.00
Leptodora kindtii	--	4.0	0.03
Total Loc 4 Biomass			0.88
Location 6 Seven Bavs			
Daphnia galeata mendotae		--	*0.00*
Daphnia retrocurva	0.40-1.70	1.0	1.05
Daphnia pulex	0.50-2.00	1.0	1.52
Daphnia thorata		--	*0.00*
Leptodora kindtii	1.00-13.00	4.0	0.03
Total Loc 6 Biomass			**2.59**
Location 9 Spring Canyon			
Daphnia galeata mendotae		1.0	*0.00*
Daphnia retrocurva	0.50-2.00	0.9	0.38
Daphnia pulex	0.50-1.70		1.51
Daphnia thorata		--	*0.00*
Leptodora kindtii	3.00-15.00	4.0	0.05
Total Loc 9 Biomass			**1.94**

Table B.35 Representative zooplankton size ranges (mm), mean lengths (mm) and biomass values (mg/m³) for samples collected at four locations in July, 1996 on Lake Roosevelt.

	Size range (mm)	Mean length (mm)	Biomass (mg/m³)
Location 2 Gifford			
Daphnia galeata mendotae	--	0.6	*0.00*
Daphnia retrocurva	0.40-0.70	0.6	<0.01
Daphnia pulex	0.40-0.70		0.01
Daphnia thorata	--	--	*0.00*
Leptodora kindtii	--	--	*0.00*
Total Loc 2 Biomass			**0.02**
Location 4 Porcupine Bay			
Daphnia galeata mendotae		1.5	0.06
Daphnia retrocurva	0.50-2.40	1.6	6.83
Daphnia pulex	0.60-2.80		129.14
Daphnia thorata			*0.00*
Leptodora kindtii	3.00-14.00	5-i	5.83
Total Loc 4 Biomass			**141.86**
Location 6 Seven Bays			
Daphnia galeata mendotae		--	*0.00*
Daphnia retrocurva	0.50-2.40	1.2	4.35
Daphnia pulex	0.40-2.30	1.2	22.37
Daphnia thorata	--	--	*0.00*
Leptodora kindtii	2.00-15.00	6.8	7.15
Total Loc 6 Biomass			33.87
Location 9 Spring Canyon			
Daphnia galeata mendotae		--	*0.00*
Daphnia retrocurva	0.40-2.00	1.4	14.96
Daphnia pulex	0.50-2.70	1.5	86.32
Daphnia thorata		--	*0.00*
Leptodora kindtii	2.00-8.00	5.0	1.92
Total Loc 9 Biomass			**103.20**

Table B.36 Representative zooplankton size ranges (mm), mean lengths (mm) and biomass values (mg/m^3) for samples collected at four locations in August, 1996 on Lake Roosevelt.

	Size range (mm)	Mean length (mm)	Biomass (mg/m^3)
Location 2 Gifford			
Daphnia galeata mendotae	--	0.8	*0.00*
Daphnia retrocurva	0.40-1.50	0.9	*0.36*
Daphnia pulex	0.40-1.30		*0.40*
Daphnia thorata	--	--	*0.00*
Leptodora kindtii	--	--	*0.00*
Total Loc 2 Biomass			0.76
Location 4 Porcupine Bay			
Daphnia galeata mendotae	--	--	*0.00*
Daphnia retrocurva	--	--	*0.00*
Daphnia pulex	0.70-2.60	1.7	80.60
Daphnia thorata	--	--	*0.00*
Leptodora kindtii	--	--	*0.00*
Total Loc 4 Biomass			**80.60**
Location 6 Seven Bays			
Daphnia galeata mendota	0.40-2.10	1.1	0.30
Daphnia retrocurva	0.40-1.80	1.2	0.91
Daphnia pulex	0.60-3.10		20.04
Daphnia thorata	--		*0.00*
Leptodora kindtii	4.00-11.00	6.5	0.94
Total Loc 6 Biomass			22.83
Location 9 Spring Canyon			
Daphnia galeata mendotae		--	
Daphnia retrocurva	0.30-2.00	1.1	1.62
Daphnia pulex	0.50-2.70	1.3	57.96
Daphnia thorata	--	--	
Leptodora kindtii		4.8	1.02
Total Loc 9 Biomass			60.60

Table B.37 Representative zooplankton size ranges (mm), mean lengths (mm) and biomass values (mg/m^3) for samples collected at four locations in September, 1996 on Lake Roosevelt.

	Size range (mm)	Mean length (mm)	Biomass (mg/m^3)
'Location 2 Gifford			
Daphnia galeata mendotae			*0.00*
Daphniu retrocurva	0.50-1.40	0.9	0.19
Daphnia pulex	0.70-l .90	1.2	*27.70*
Daphnia thorata	--	--	*0.00*
Leptodora kindtii	--	6.00	0.10
Total Loc 2 Biomass			**27.98**
Location 4 Porcupine Bay			
Daphnia galeata mendotae		--	*0.00*
Daphnia retrocurva	0.40-1.20	0.8	*0.05*
Daphnia pulex	0.50-2.60	1.5	11.62
Daphnia thorata			*0.00*
Leptodora kindtii			0.35
Total Loc 4 Biomass	4.00-1.00	7.5	**12.03**
Location 6 Seven Bays		0.8	
	0.50- 1.00	0.9	0.08
Daphniu retrocurva	0.50- 1.50		1.58
Daphnia pulex	0.50-2.10	1.2	30.31
Daphnia thorata	--	--	*0.00*
Leptodora kindtii	--	--	*0.00*
Total Loc 6 Biomass			**31.98**
Location 9 Spring Canyon			
Daphniu galeata mendotae	0.50-l-70	1.1	0.43
Daphniu retrocurva	0.40-2.50	1.0	0.46
Daphnia pulex	0.50-2.40	1.5	76.07
Daphnia thorata		--	*0.00*
Leptodora kindtii	2.00-6.00	3.9	2.42
Total Loc 9 Biomass			**79.39**

Table B.38 Representative zooplankton size ranges (mm), mean lengths (mm) and biomass values (mg/m^3) for samples collected at three locations in October, 1996 on Lake Roosevelt.

	Size range (mm)	Mean length (mm)	Biomass (mg/m^3)
Location 2 Gifford			
Daphnia galeata mendotae		0.7	*0.00*
Daphnia retrocurva	0.40-1 .00	0.9	*0.05*
Daphnia pulex	0.50-1.80		*6.36*
Daphnia thorata	--	--	*0.00*
Leptodora kindtii	--	--	*0.00*
Total Loc 2 Biomass			**6.41**
Location 4 Porcupine Bay			
Daphniu galeata mendotae			*0.00*
Daphniu retrocurva	0.70-1.40	1.0	*0.04*
Daphnia pulex	0.60-2.70	1.5	182.55
Daphnia thorata		--	*0.00*
Leptodora kindtii	3.00-5.00	4.0	0.03
Total Loc 4 Biomass			**182.59**
Location 9 Spring Canyon			
Daphnia galeata mendotae	--	--	*0.00*
Daphnia retrocurva			*0.00*
Daphnia pulex	0.50-2.30	1.1	4.71
Daphnia thorata	--	--	*0.00*
Leptodora kindtii	--	--	*0.00*
Total Loc 9 Biomass			4.71

Table B.39 Representative zooplankton size ranges (mm), mean lengths (mm) and biomass values (mg/m^3) for samples collected at four locations in November, 1996 on Lake Roosevelt.

	Size range (mm)	Mean length (mm)	Biomass (mg/m^3)
Location 2 Gifford			
Daphniu galeata mendotae	--	--	*0.00*
Daphnia retrocurva			*0.00*
Daphnia pulex	0.40-2.00	1.0	0.11
Daphnia thorata	--	--	*0.00*
Leptodora kindtii	--	--	*0.00*
Total Loc 2 Biomass			**0.11**
Location 4 Porcupine Bay			
Daphnia galeata mendotae	--	--	*0.00*
Daphnia retrocurva		--	*0.00*
Daphnia pulex	0.50-2.00	1.0	7.47
Daphnia thorata	--	--	*0.00*
Leptodora kindtii	--	--	*0.00*
Total Loc 4 Biomass			7.47
Location 6 Seven Bays			
Daphnia galeata mendotae	--	--	*0.00*
Daphniu retrocurva		--	*0.00*
Daphnia pulex	0.5.0-2.50	1.2	36.25
Daphnia thorata	--	--	*0.00*
Leptodora kindtii	--	--	*0.00*
Total Loc 6 Biomass			36.25
Location 9 Spring Canyon			
Daphnia galeata mendotae	--	--	*0.00*
Daphnia retrocurva			*0.00*
Daphnia pulex	0.50-2.20	1.4	2.47
Daphnia thorata	--	--	*0.00*
Lep todora kindtii	--	--	*0.00*
Total Loc 9 Biomass			2.47

Table B.40 Representative zooplankton size ranges (mm), mean lengths (mm) and biomass values (mg/m^3) for samples collected at two locations in December, 1996 on Lake Roosevelt.

	Size range (mm)	Mean length (mm)	Biomass (mg/m^3)
Location 2 Gifford			
Daphnia galeata mendotae	--	--	*0.00*
Daphnia retrocurva	--		*0.00*
Daphnia pulex	0.60-2.50	1.0	0.07
Daphniu thorata	--	--	*0.00*
Lep todora kindtii	--	--	*0.00*
Total Loc 2 Biomass			**0.07**
Location 4 Porcupine Bay			
Daphnia galeata mendotae	--	--	*0.00*
Daphnia retrocurva	--		*0.00*
Daphnia pulex	0.90-2.50	1.7	119.05
Daphnia thorata	--	--	*0.00*
Leptodora kindtii	--	--	*0.00*
Total Loc 4 Biomass			**119.05**
Location 6 Seven Bays			
Daphniu galeata mendotae	--	--	*0.00*
Daphniu retrocurva		--	*0.00*
Daphnia pulex	0.60-2.60	1.2	1.83
Daphnia thorata	--	--	*0.00*
Leptodora kindtii	--	--	*0.00*
Total Loc 6 Biomass			**1.83**
Location 9 Spring Canyon			
Daphnia galeata mendotae	--	--	*0.00*
Daphnia retrocurva		--	*0.00*
Daphnia pulex	0.70-2.70	1.4	79.20
Daphnia thorata	--	--	*0.00*
Leptodora kindtii	--	--	*0.00*
Total Loc 9 Biomass			**79.20**

APPENDIX C

Water Quality

Table C.l-6 Water quality measurements taken with a Hydrolab Surveyor II at Gifford, Porcupine Bay, Confluence, Seven Bays, Keller Ferry and Spring Canyon in March, 1996.

Table C.l;

GIFFORD

Depth (m)	Temp. (°C)	PH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	2.29	6.87	14.82	0.160	202
3	2.25	7.10	12.76	0.160	202
6	2.20	7.17	12.60	0.158	203
9	2.18	7.20	12.53	0.159	203
12	2.18	7.23	12.46	0.157	203
15	2.18	7.25	12.46	0.159	203
18	2.18	7.28	12.36	0.159	204

Table C.2;

PORCUPINE BAY

Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	3.23	7.00	20.18	0.091	203
3					
6	3.06 3.04 7.00 7.02 15.17 13.33 0.090 0.089 [illegible]				.
9	3.05	7.02	12.90	0.090	205
12	3.06	7.02	12.73	0.091	206
15	3.06	7.02	12.73	0.091	206
18	3.06	7.02	12.65	0.090	207
21	3.06	7.02	12.65	0.09 1	207

Table C.3;

CONFLUENCE

Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	2.59	6.99	18.44	0.106	206
3					
6	2.58 2.54	7.00 6.99	14.50 12.88	0.106 0.114	206 206
9	2.49	7.00	12.34	0.132	206
12	2.48	7.04	12.22	0.136	205
18	2.47	7.08	12.10	0.138	205
21	2.44 2.34	[illegible]	12.04 11.98	0.141 0.144	204
					204
24	2.45	7.16	11.84	0.150	204
27					
30	2.45 2.42	7.20 7.24	11.88 11.89	0.154 0.148	205 204
33,	2.43	7.22	11.89	0.154	204

Table C.4;

SEVEN BAYS					
Depth (m)	**Temp. (°C)**	**pH**	**D.O. (mg/L)**	**Conduct. mmho/cm**	**ORP (mV)**
0	3.51	7.08	18.97	0.150	211
3					
6	3.54 3.41	7.13 7.18	13.08 14.19	0.151 0.150	'212 212
9	3.36	7.20	12.94	0.150	213
12	3.42	7.22	12.91	0.150	213
15	3.42	7.23	12.86	0.152	213
18	3.31	7.23	12.93	0.152	214
21					
24	3.30 3.29	7.24 7.25	12.93 12.95	0.151 0.151	214 214
27					
30	3.28 3.27	7.25 7.26	12.97 12.97	0.151 0.151	214 214
33	3.26	7.25	12.96	0.151	214

Table C.5;

KELLER FERRY					
Depth (m)	**Temp. (°C)**	**pH**	**D.O. (mg/L)**	**Conduct. mmho/cm**	**ORP (mV)**
0	2.76	7.29	17.16	0.150	174
z	2.73 2.70	7.31 7.31	15.57 13.31	0.149 0.149	171 171
9	2.68	7.32	12.64	0.148	171
12	2.67	7.32	12.39	0.150	172
15	2.68	7.33	12.21	0.147	172
18					
21	2.66 2.67	7.33 7.33	12.12 12.04	0.149 0.148	172 172
24					
27	2.68 2.68	7.33 7.34	12.04 12.04	0.147 0.147	173 173
30					
33	2.68 2.68	7.34 7.34	12.04 12.04	0.147 0.147	173 174

Table C.6;

SPRING CANYON					
Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	2.71	7.35	17.02	0.149	198
3					
6	2.72 2.66	7.35 7.34	13.99 12.73	0.148 0.148	199 199
9	2.66	7.34,	12.57	0.147	199
12	2.65	7.34	12.41	0.148	200
15	2.65	7.33	12.32	0.147	200
18	2.65	7.33	12.32	0.146	200
21					
24	2.65 2.65	7.33 7.33	12.32 12.23	0.147 0.147	200 201
27					
30	2.65 2.65	7.33 7.33	12.23 12.23	0.144 0.146	201 201
33	2.65	7.33	12.23	0.144	201

Table C.7-9 Water quality measurements taken with a Hydrolab Surveyor II at Seven Bays, Keller Ferry and Spring Canyon in April,, 1996.

Table C.7;

SEVEN BAYS

Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	5.78	8.64	12.35	0.155	318
3	5.65	8.65	12.13	0.116	322
6	5.53	8.65	12.27	0.117	325
9	5.45	8.65	12.28	0.119	328
12	5.38	8.65	12.27	0.117	330
15	5.38	8.64	12.28	0.117	333
18	5.37	8.65	12.28	0.119	336
21	5.33	8.64	12.24	0.120	338
24	5.33	8.64	12.26	0.117	339
27	5.33	8.64	12.22	0.117	342
30	5.30	8.65	11.86	0.116	334

Table C.8;

KELLER FERRY

Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	7.31	8.56	10.88	0.117	307
3					
6	7.21 7.19	8.59 8.60	10.95 10.86	0.117 0.117	308 309
‘9	7.19	8.60	10.92	0.117	310
12	7.19	8.60	10.79	0.118	311
15	7.19	8.60	10.80	0.116	311
18					
21	7.19 7.20	8.60 8.60	10.78 10.80	0.115 0.116	312 312
24	7.19	8.60	10.80	0.118	313
27	7.20	8.60	10.70	0.116	314
30					
33	7.20 7.20	8.60 8.60	10.70 10.70	0.119 0.116	314 314

Table C.9;

SPRING CANYON					
Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	7.55	8.68	11.34	0.121	310
3	6.62	8.72	11.26	0.121	311
6	6.50	8.73	11.54	0.121	311
9	6.42	8.72	11.50	0.119	312
12	6.35	8.71	11.34	0.122	313
15	6.35	8.67	11.31	0.120	313
18	6.32	8.69	11.36	0.121	314
21	6.29	8.68	11.31	0.121	314
24	6.31	8.68	11.25	0.122	315
27	6.27	8.67	11.33	0.120	316
30	6.26	8.67	11.31	0.122	316
33	6.24	8.67	11.18	0.123	317

Table C.l0-17 Water quality measurements taken with a Hydrolab Surveyor II at Kettle Falls, Gifford, Hunters, Porcupine Bay, Seven Bays, Keller Ferry, San Poil and Spring Canyon in May, 1996.

Table C.10;

KETTLE FALLS

Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	7.08	8.47	13.05	0.122	345
3					344
6	7.03 7.04	8.54 8.57	11.70 11.60	0.121 0.122	344
9	7.04	8.58	11.56	0.122	344
12	7.03	8.60	11.53	0.120	345
15	7.03	8.61	11.47	0.123	345
18	7.03	8.62	11.46	0.122	345
21	7.03	8.63	11.47	0.122	346

Table C.ll;

GIFFORD

Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	7.47	8.44	10.65	0.122	326
3					
6	7.44 7.54	8.48 8.51	11.12 11.19	0.125 0.124	326 325
9	7.39	8.54	11.18	0.124	325
12	7.39	8.58	10.96	0.126	325
15					
18	7.39 7.37	8.60 8.61	10.95 10.96	0.122 0.123	325 325
21	7.39	8.62	10.93	0.126	325
24					
27	7.37 7.37	8.62 8.64	11.08 11.03	0.125 0.126	325 326
30	7.37	8.66	11.12	0.121	325
33	7.39	8.66	11.27	0.124	326

Table C.12;

		HUNTERS			
Depth (m)	**Temp. (°C)**	**pH**	**D.O. (mg/L)**	**Conduct. mmho/cm**	**ORP (mV)**
0	7.52	8.66	14.95	0.125	362
3					
6	7.54 7.49	8.67 8.68	11.80 11.48	0.126	366 371
9	7.49	8.69	11.45	0.132	375
12	7.50	8.70	11.39	0.126	378
15	7.47	8.70	11.33	0.128	381
18	7.47	8.70	11.31	0.125	382
21	7.47	8.71	11.31	0.124	384
24	7.47	8.70	11.25	0.125	386
27					
30	7.49 7.47	8.71 8.71	11.24 11.25	0.126 0.122	387 389
33	7.47	8.71	11.23	0.121	390

Table C.13;

		PORCUPINE BAY			
Depth (m)	**Temp. (°C)**	**pH**	**D.O. (mg/L)**	**Conduct. mmho/cm**	**ORP (mV)**
0	8.32	8.89	11.39	0.058	338
3					
6	8.34 8.30	8.21 8.22	11.01 10.93	0.059 0.059	338 339
9					
12	8.27 8.26	8.23 8.23	10.86 10.85	0.057 0.060	340 340
15	8.26	8.24	10.82	0.056	341
18	8.26	8.23	10.78	0.060	342

Table C.14;

		SEVEN BAYS			
Depth (m)	**Temp. (°C)**	**pH**	**D.O. (mg/L)**	**Conduct. mmho/cm**	**ORP (mV)**
0	8.89	8.55	12.06	0.100	311
3	8.78	8.58	10.95	0.104	310
6					
9	8.48 8.40	8.60 8.60	10.78	0.103 0.108	311 311
12	8.32	8.63	10.63	0.111	311
15	8.22	8.64	10.66	0.115	312
18	8.21	8.65	10.81	0.115	312
21	8.19	8.16	10.82	0.115	312
24					
27	8.19 8.14	8.16 8.67	10.79 10.82	0.114 0.117	312 313
30	8.11	8.68	10.74	0.116	314
33	8.12	8.68	10.65	0.116	314

Table C.15;

KELLER FERRY

Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	11.05	8.92	11.10	0.116	337
3	9.79	8.97	11.04	0.117	340
6	9.42	8.94	10.91	0.118	341
9	9.30	8.90	10.78	0.118	343
12	8.52	8.85	10.80	0.116	346
15	8.30	8.81	10.80	0.118	347
18	8.26	8.79	10.77	0.118	348
21	8.26	8.77	10.74	0.115	350
24	8.24	8.75	10.56	0.119	351
27	8.24	8.75	10.64	0.115	351
30	8.22	8.74	10.60	0.119	352
33	8.22	8.75	10.47	0.118	352

Table C.16;

SAN POIL RIVER

Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	12.5 1	8.43	8.76	0.116	351
3					
6	10.33 8.79	8.51 8.53	10.19 8.51	0.113 0.115	354 354
9	8.44	8.55	10.63	0.118	354
12	8.34	8.58	10.79	0.114	354
15	8.27	8.59	10.78	0.116	355
18	8.24	8.60	10.72	0.117	355
21	8.17	8.57	9.90	0.112	356

Table C.17;

SPRING CANYON

Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	9.84	8.55	13.28	0.130	289
3					
6	9.77 9.55	8.55 8.54	10.19 9.90	0.130 0.125	289 290
9	9.53	8.53	9.84	0.128	291
12	9.53	8.52	9.74	0.128	292
15	9.53	8.52	9.70	0.129	293
18	9.53	8.51	9.69	0.132	293
21	9.53	8.51	9.66	0.130	294
24	9.53	8.51	9.66	0.128	295
27	9.53	8.50	9.61	0.128	296
30	9.53	8.50	9.59	0.130	296
33	9.53	8.50	9.60	0.130	297

Table C.18-22 Water quality measurements taken with a Hydrolab Surveyor II at Gifford, Confluence, Seven Bays, Keller Ferry and Spring Canyon in June, 1996.

Table C.18;

GIFFORD

Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	12.44	8.55	9.53	0.129	329
3	12.34	8.56	9.56	0.129	329
6	12.26	8.55	9.57	0.128	330
9	12.26	8.55	9.47	0.128	330
12	12.28	8.55	9.48	0.128	331
15	12.26	8.55	9.47	0.129	331
18	12.26	8.55	9.46	0.162	332
21	12.26	8.55	9.43	0.127	332
24	12.24	8.55	9.41	0.130	332
27	12.24	8.55	9.39	0.127	333
30	12.24	8.55	9.39	0.127	334
33	12.24	8.55	9.40	0.129	334

Table C.19;

CONFLUENCE

Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	14.57	8.85	10.46	0.098	307
3	12.69	8.78	9.61	0.113	312
6	12.34	8.69	9.47	0.116	314
9	12.18	8.64	9.48	0.120	315
12	12.11	8.62	9.49	0.122	317
15	11.80	8.59	9.54	0.124	318
18	11.72	8.56	9.56	0.127	319
21	11.59	8.55	9.59	0.127	320
24	11.51	8.54	9.57	0.127	320
27	11.47	8.53	9.53	0.125	321
30	11.46	8.51	9.41	0.125	322
33	11.46	8.51	9.48	0.126	323

Table C.20;

SEVEN BAYS

Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	13.25	8.36	12.66	0.112	339
3	12.77	8.41	9.73	0.116	338
6	12.52	8.44	9.63	0.119	337
9	11.95	8.46	9.61	0.124	337
12	11.90	8.47	9.65	0.124	337
15	11.82	8.47	9.62	0.128	337
18	11.75	8.48	9.63	0.127	337
21	11.69	8.47	9.62	0.128	339
24	11.65	8.47	9.61	0.168	339
27	11.67	8.48	9.63	0.130	339
30	11.57	8.47	9.60	0.124	339
33	11.54	8.47	9.60	0.124	340

Table C.21;

KELLER **FERRY**

Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	15.54	8.74	11.81	0.136	277
3					
6	14.45 14.31	8.70 8.69	11.98 11.90	0.137 0.138	281 282
9	14.23	8.67	11.85	0.137	284
12	14.14	8.66	11.80	0.138	285
15		8.64			
18	14.01 13.95	8.63	11.82 11.71	0.137 0.137	286 287
21	13.80	8.62	11.75	0.138	287
24	13.79	8.62	11.74	0.138	289
27	13.79	8.61	11.74	0.137	289
30					
33	13.79 13.78	8.60 8.61	11.71 11.75	0.137 0.137	289 290

Table C.22;

SPRING **CANYON**

Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	14.08	8.91	8.85	0.129	289
3					
6	13.00 12.74	8.94 8.84	10.03 9.65	0.129 0.129	290 293
9	12.52	8.29	9.64	0.128	294
12					
15	11.93 11.60	8.69 8.62	9.66 9.58	0.130 0.129	298 301
18	11.42	8.57	10.08	0.130	303
21	11.39	8.55	9.40	0.128	304
24					
27	11.33 11.28	8.53	9.35 9.29	0.129 0.128	305 306
30	11.20	8.52	9.19	0.130	307
33	11.07	8.51	9.17	0.127	308

Table C.23-30 **Water quality measurements taken with a Hydrolab Surveyor II at Kettle Falls, Gifford, Hunters, Porcupine Bay, Seven Bays, Keller Ferry, San Poil and Spring Canyon in July, 1996.**

Table C.23;

KETTLE FALLS

Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
3	16.22	8.46	13.01	0.134	223
6	16.04 16.12	8.63 8.61	12.07 11.93	0.133	230
				0.133	230
9	16.07	8.65	11.91	0.133	232
12	16.05	8.67	11.78	0.132	238
15	16.05	8.67	11.71	0.131	239
18	16.05	8.68	11.68	0.132	239
24	16.06	8.69	11.68,	0.132	240
27	16.00 16.01	8.69 8.69	11.65 11.63	0.133	241
				0.131	242
30	15.99	8.69	11.63	0.133	242
33	16.00	8.69	11.65	0.131	243

Table C.24;

GIFFORD

Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
3	17.66	8.53	18.42	0.134	202
6	16.64 16.59	8.58 8.59	12.76 12.34	0.135	207
				0.135	208

Table C.25

HUNTERS

Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
3	18.12	8.70	12.06	0.135	200
6	18.03 17.84	8.71 8.73	11.59 11.21	0.135 0.134	201
					203
9	17.75	8.74	11.14	0.134	204
12	17.62	8.73	--	--	--

Table C.26;

PORCUPINE BAY

Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	20.58	8.50	9.46	0.138	201
3					
6	20.49 20.44	8.55 8.55	9.32 9.30	0.138 0.137	203 205
9	20.36	8.59	9.22	0.138	206
12	18.23	8.50	8.76	0.129	213
15	16.34	8.25	7.84	0.113	225
18					
21	15.51 13.81	8.20 8.20	8.36 8.85	0.106 0.104	228 230
24	13.40	8.16	9.25	0.107	234
27	13.15	8.12	8.94	0.108	236
30	13.02	8.12	8.74	0.109	237
33	12.79	8.11	8.37	0.109	239

Table C.27;

SEVEN BAYS

Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	19.11	8.83	14.12	0.137	200
3					
6	18.96 18.30	8.79 8.77	12.07 11.89	0.135 0.135	203 207
9	17.70	8.75	11.64	0.135	211
12	17.21	8.68	11.35	0.134	214
15	16.96	8.63	11.24	0.133	217
18	16.72	8.60	11.14	0.134	219
21	16.59	8.57	11.11	0.134	220
24	16.53	8.55	11.09	0.133	223
27	16.37	8.55	11.06	0.133	224
30	16.26	8.53	11.08	0.134	226
33	16.21	8.52	11.08	0.132	227

Table C.28;

Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
		KELLER FERRY			
0	19.86	8.74	14.45	0.139	196
3					
6	19.12 18.70	8.78 8.81	12.52 12.24	0.136 0.135	197 199
9	17.73	8.81	12.07	0.136	201
12	17.00	8.75	11.65	0.136	206
15	16.68	8.71	11.54	0.135	209
18	16.66	8.67	11.47	0.133	211
21	16.65	8.65	11.39	0.134	212
24					
27	16.42 16.41	8.64 8.64	11.36 11.33	[illegible]	214 215
30	16.21	8.62	11.31	0.135	217
33	16.15	8.60	11.32	0.134	219

Table C.29;

Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
		SAN POIL RIVER			
0	19.87	8.41	13.28	0.146	195
3	19.21	8.47	11.74	0.144	196
6					
9	17.67 17.34	8.62 8.60	11.96 11.80	0.138 0.137	195 197
12	17.21	8.62	11.68	0.136	200
15	17.03	8.62	11.60	0.135	201
18					
21	16.70 16.55	8.62 8.60	11.53 11.47	0.136 0.133	203 205
24	16.50	8.58	11.38	0.135	207
27	16.41	8.57	11.30	0.132	208
30					
33	16.31 16.21	8.55 8.53	11.25 11.04	0.144 0.137	209 211

Table C.30;

SPRING CANYON					
Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	20.97	8.92	10.16	0.136	190
3	20.62	8.98	10.51	0.136	189
6	20.26	9.01	10.92	0.135	188
9	20.03	9.03	11.20	0.135	188
12	20.00	9.02	11.17	0.136	189
15	19.37	8.98	11.18	0.135	192
18	18.44	8.91	11.28	0.134	197
21	18.32	8.84	11.30	0.134	199
24	17.97	8.79	11.09	0.135	201
27	17.84	8.76	10.98	0.134	202
30	17.81	8.75	10.91	0.134	203
33	17.81	8.73	10.88	0.134	203

Table C.31-36 Water quality measurements taken with a Hydrolab Surveyor II at Gifford, Porcupine Bay, Confluence, Seven Bays, Keller Ferry, and Spring Canyon in August, 1996.

Table C.31;

GIFFORD

Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	20.06	8.96	10.69	0.136	176
3					
6	17.79 17.35	9.01 8.93	12.53 12.58	0.137 0.136	181 185
9	17.29	8.90	12.45	0.136	187
12	17.10	8.87	12.37	0.136	198
15	17.06	8.84	12.01	0.135	191
18	17.05	8.82	11.96	0.136	193
21					
24	17.03 17.00	8.81 8.80	11.89 11.65	0.135 0.134	194 196
27	17.02	8.80	11.56	0.135	197
30	16.90	8.79	11.36	0.135	199
33	16.84	8.77	11.20	0.133	200

Table C.32;

PORCUPINE BAY

Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
3	21.96	8.97	9.59	0.159	194
6	21.70 21.57	8.82 8.82	8.52 8.35	0.157 0.155	202 201
9	19.70	8.77	7.13	0.153	211
12	18.59	8.69	8.18	0.136	214
15	18.65	8.69	9.10	0.135	213
18					
21	17.43 17.00	8.69 8.67	9.39 8.99	0.134 0.132	215 218
24					
27	16.28 15.31	8.63 8.59	7.18 8.42	0.127 0.150	221 226
30					
33	13.40 14.10	8.33 8.50	6.33 5.87	0.111 0.111	229 232

Table C.33;

CONFLUENCE

Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	21.37	8.99	9.42	0.144	222
3					
6	20.07 19.36	9.02 9.08	10.62 9.93	0.139 0.135	221 220
9	18.33	9.04	10.55	0.135	226
12	17.84	8.92	9.41	0.136	230
15	17.74	8.85	9.50	0.134	23i
18					232
21	17.54 17.28	8.83 8.80	9.46 9.34	0.135 0.133	234
24	16.98	8.78	10.76	0.135	235
27					
30	16.91 16.77	8.74 8.72	9.50 9.43	0.133 0.133	237 238
33	16.73	8.70	9.52	0.133	239

Table C.34;

SEVEN BAYS

Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	20.69	9.16	10.01	0.158	207
3	19.45	9.11	10.27	0.135	211
6	18.39	9.08	9.68	0.136	215
9	37.87	9.00	9.56	0.135	220
12	17.72	8.93	9.33	0.135	222
15	17.66	8.90	9.53	0.133	223
18	17.55	8.87	9.92	0.134	225
21	17.48	8.86	9.71	0.134	226
24	17.21	8.84	9.55	0.131	227
27	17.08	8.81	9.87	0.133	229
30	17.03	8.79	9.89	0.132	229
33	16.99	8.78	9.97	0.133	230

Table C.35;

KELLER FERRY

Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	20.05	8.68	11.37	0.136	239
3					
6	19.91 19.81	8.85 8.96	10.96 10.70	0.136 0.136	242 238
9	19.80	9.02	10.52	0.136	236
12	19.63	8.99	10.46	0.135	236
15	18.80	8.90	10.21	0.136	241
18	18.27	[illegible]	10.37	0.134	244
21	18.04	8.85	10.35	0.134	245
24	17.85	8.81	10.33	0.135	247
27					
30	17.77 17.45	8.79 8.76	10.32 10.31	0.134 0.134	248 250
33	17.35	8.74	10.32	0.134	250

Table C.36;

SPRING CANYON

Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	20.33	8.42	12.24	0.136	226
3	20.12	8.76	10.21	0.136	222
6	19.95	8.87	10.10	0.136	221
9	19.92	8.92	9.96	0.136	221
12	19.63	8.94	9.89	0.136	223
15	18.69	8.89	9.96	0.135	226
18	18.24	8.83	10.10	0.134	228
21	17.92	8.80	10.17	0.135	230
24	17.76	8.77	10.15	0.135	232
27	17.60	8.74	10.16	0.134	233
30	17.51	8.72	10.14	0.134	235
33	17.37	8.70	10.16	0.132	236

Tables C.37-42 **Water quality measurements taken with a Hydrolab Surveyor II at Gifford, Porcupine Bay, Confluence, Seven Bays, Keller Ferry, and Spring Canyon in September, 1996.**

Table C.37;

GIFFORD

Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	17.81	9.00	12.07	0.135	229
3	17.80	8.97	10.53	0.135	231
6	17.33	8.94	10.37	0.135	233
9	16.81	8.91	10.39	0.134	235
12	16.63	8.89	10.41	0.133	237
15	16.58	8.87	10.40	0.133	237
18	16.42	8.87	10.49	0.132	238
21	16.34	8.86	10.44	0.132	238
24	16.34	8.86	10.42	0.131	239
27	16.34	8.86	10.43	0.131	240
30	16.34	8.85	10.42	0.131	239
33	16.27	8.85	10.42	0.132	240

Table C.38;

PORCUPINE BAY

Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	19.24	8.98	10.06	0.172	223
3	19.20	8.92	9.15	0.17[illegible]	224
6	19.01	8.82	8.27	0.167	229
9	18.62	8.72	8.04	0.152	232
12	18.01	8.68	8.81	0.138	233
15	17.86	8.63	8.57	0.136	236
18	17.66	8.54	8.44	0.137	241
21	17.55	8.52	8.38	0.134	242
24	[illegible]	[illegible]	[illegible]	[illegible]	244
27	[illegible]	[illegible]	[illegible]	[illegible]	245
30	16.12	8.43	6.88	0.125	248
33	14.19	8.36	5.30	0.119	253

Table C.39;

		CONFLUENCE			
Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	18.52	8.97	9.95	0.148	243
3					
6	18.54 18.22	8.93 8.94	9.97 9.91	0.140 0.148	245 245
9	18.01	8.90	9.86	0.136	246
12	17.88	8.86	9.77	0.136	248
15					
18	17.87 17.80	8.85 8.82	9.75 9.68	0.135 0.135	249 250
21	17.68	8.80	9.66	0.135	251
24	17.60	8.78	9.58	0.134	252
27	17.55	8.75	9.51	0.135	254
30	17.53	8.73	9.49	0.134	254
33	17.53	8.72	9.49	0.134	255

Table C.40;

		SEVEN BAYS			
Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	18.22	9.02	10.14	0.138	233
3	18.23	8.89	10.07	0.137	236
6	18.16	8.97	10.10	0.136	236
9	18.14	8.97	10.03	0.136	237
12	18.10	8.97	9.96	0.135	236
15	18.01	8.94	9.92	0.135	239
18	17.87	8.90	9.86	0.135	240
21	17.82	8.88	9.80	0.135	241
24	17.79	8.85	9.76	0.135	242
27	17.77	8.84	9.72	0.135	243
30	17.73	8.83	9.69	0.134	244
33	17.60	8.80	9.60	0.134	245

Table C.41;

KELLER FERRY					
Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	17.44	7.98	11.22	0.128	177
3					
6	17.15 17.12	7.86 7.82	9.62 9.33	0.128 0.128	183 187
9	17.10	7.78	9.21	0.129	188
12	17.09	7.77	9.12	0.127	190
15	17.11	7.76	9.08	0.128	191
18	17.10	7.75	9.07	0.128	192
21					
24	17.10 17.10	7.75 7.75	9.03 8.99	0.127 0.128	193 194
27	17.10	7.75	8.99	0.130	195
30	17.10	7.75	8.99	0.129	196
33	17.09	7.75	9.04	0.129	196

Table C.42;

SPRING CANYON					
Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	19.42	9.10	10.91	0.137	228
3					
6	19.34 19.17	9.06 9.06	10.15 9.83	0.137 0.137	230 232
9	18.86	9.04	9.72	0.136	234
12	18.57	8.99	9.66	0.136	236
15	18.42	8.95	9.60	0.136	238
18	18.31	8.92	9.60	0.136	239
21	18.21	8.88	9.62	0.135	241
24	18.14	8.85	9.58	0.135	242
27	18.02	8.81	9.59	0.134	244
30					
33	17.95 17.83	8.79 8.76	9.60 9.62	0.135 0.134	246 247

Table C.43-46 Water quality measurements taken with a Hydrolab Surveyor II at Kettle Falls, Gifford, Hunters, and Keller Ferry in October, 1996.

Table C.43;

KETTLE FALLS

Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	13.00	8.44	12.22	0.121	369
3					
6	13.00 13.02	9.04 8.82	11.61 11.51	0.123 0.121	364 364
9	13.02	9.08	11.26	0.123	365
12	13.00	9.12	11.17	0.121	366
15	13.02	9.14	11.22	0.123	368
18	13.02	9.16	11.12	0.123	370
21					
24	13.02	9.17 9.18	11.14 11.10	0.132 0.120	371 372
27	13.00	9.18	11.11	0.125	374
30					
33	13.00 13.00	9.19 9.19	11.05 11.08	0.124 0.124	375 375

Table C.44;

GIFFORD

Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	14.62	8.62	11.27	0.211	344
3	13.98	8.89	11.10	0.121	344
6	13.90	8.98	11.01	0.122	336
9	13.90	9.11	10.83	0.122	336
12	13.81	9.13	10.85	0.124	336
15	13.66	9.13	10.72	0.122	336
18	13.64	9.13	10.67	0.123	337
21	13.64	9.14	10.65	0.121	337
24	13.64	9.14	10.53	0.124	3 3 7
27	13.64	9.15	10.61	0.124	338
30	13.64	9.15	10.61	0.124	338
33	13.64	9.15	10.55	0.124	339

Table C.45;

HUNTERS

Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	14.33	7.98	11.18	0.120	360
3					
6	14.07 14.09	8.63 8.81	10.88 10.72	0.121 0.121	346 342
9	13.95	8.90	10.77	0.119	340
12	13.92	8.96	10.83	0.123	339
15	13.89	9.00	10.90	0.119	339
18	13.86	9.04	10.86	0.120	338
21	13.87	9.07	10.94	0.120	338
24	13.84	9.09	10.85	0.122	338
27	13.84	9.09	10.98	0.122	338
30					
33	13.84 13.83	9.10 9.10	10.58 1064	0.122 0.121	338 339

Table C.46;

KELLER FERRY

Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	15.83	8.70	9.33	0.125	396
3	15.83	8.80	9.50	0.125	394
6	15.83	8.85	9.46	0.126	394
9	15.83	8.89	9.62	0.125	393
12	15.81	8.93	9.62	0.124	393
15	15.81	8.96	9.60	0.126	392
18	15.83	8.99	9.60	0.124	392
21	15.81	9.00	9.59	0.124	393
24	15.75	9.01	9.65	0.127	393
27	15.73	9.02	9.65	0.121	393
30	15.66	9.03	9.55	0.125	394
33	15.55	9.04	9.65	0.127	394

Table C.47-52 Water quality measurements taken with a Hydrolab Surveyor II at Gifford, Porcupine Bay, Confluence, Seven Bays, Keller Ferry, and Spring Canyon in November, 1996.

Table C.47;

GIFFORD

Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	8.44	8.56	17.11	0.129	459
3					
6	8.39 8.40	8.80 8.93	12.55 12.21	0.128	456 455
9	8.35	9.00	12.10	0.129	455
12	8.35	9.04	12.17	0.129	455
15	8.37	9.07	12.19	0.130	455
18					
21	8.37 8.35	9.08 9.10	12.00 12.03	0.128 0.129	455 455
24					
27	8.34 8.34	9.12 9.14	11.87 11.94	0.125 0.132	456 456
30					
33	8.34 8.32	9.14 9.15	12.12 12.10	0.128 0.134	457 458

Table C.48;

PORCUPINE BAY

Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	11.15	9.14	12.55	0.200	442
3	11.17	9.17	10.85	0.199	442
6	11.17	9.19	10.55	0.200	442
9	11.17	9.20	10.57	0.198	443
12	11.17	9.21	10.54	0.20 1	443
15	11.17	9.21	10.51	0.211	444
18	11.17	9.21	10.51	0.184	444
21	10.89	9.19	10.42	0.184	446
24	10.58	9.16	10.25	0.178	447
27	10.15	9.15	10.27	0.203	449
30	10.01	9.14	10.29	0.167	450
33	9.94	9.13	10.27	0.173	452

Table C.49;

CONFLUENCE

Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	10.55	8.90	10.91	0.160	451
3					449
6	10.57 10.55	9.05 9.10	10.88 10.87	0.157 0.159	448
9	10.53	9.13	10.84	0.157	448
12	10.5 1	9.15	10.85	0.163	449
15	10.46	9.15	10.88	0.167	449
18					
21	10.45 10.43	9.16 9.17	10.89 10.90	0.147 0.147	449 450
24					
27	10.08 10.05	9.20 9.19	11.19 11.27	0.127	450 451
30	9.89	9.19 .	11.26	0.132	453
33	9.86	9.20	11.34	0.129	454

Table C.50;

SEVEN BAYS

Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	10.63	9.20	13.16	0.133	446
3					449
6	10.64 10.63	9.22 9.22	11.28 11.29	0.132 0.133	449 .
9	10.63	9.21	11.25	0.132	450
12					451
15	10.62 10.59	9.20 9.20	11.18 11.14	0.135 0.137	452
18	10.57	9.20	11.13	0.136	453
21	10.57	9.20	11.10	0.139	453
24					455
27	10.40 10.22	9.20 9.20	11.19 11.20	0.136 0.136	4 5 5
30	10.18	9.20	11.20	0.137	456
33	9.99	9.21	11.38	0.133	457

Table C.51;

		KELLERFERRY			
Depth (m)	**Temp. (°C)**	**pH**	**D.O. (mg/L)**	**Conduct. mmho/cm**	**ORP (mV)**
0	11.87	8.86	13.56	0.125	416
3					
6	11.87 11.80	9.08 9.12	10.58	0.125 0.126	415 415
9	11.74	9.13	10.60	0.128	416
12	11.74	9.15	10.65	0.125	418
15	11.74	9.15	10.55	0.124	420
18	11.74	9.16	10.55	0.126	421
21	11.74	9.17	10.57	0.126	423
24					
27	11.69 11.52	9.18 9.16	10.64 10.55	0.128 0.126	425 426
30	11.47	9.16	10.64	0.127	428
33	11.31	9.16	10.50	0.129	429

Table C.52;

		SPRING CANYON			
Depth (m)	**Temp. (°C)**	**pH**	**D.O. (mg/L)**	**Conduct. mmho/cm**	**O R P (mV)**
3	12.31	9.09	13.92	0.125	351
6	12.31 12.31	9.12 9.14	10.41 10.27	0.125 0.125	351 351
9	12.31	9.16	10.33	0.125	351
12	12.33	9.17	10.26	0.126	352
15	12.33	9.17	10.22	0.125	352
18					
21	12.33 12.33	9.17 9.17	10.29 10.35	0.125 0.129	353 353
24	12.34	9.17	10.37	0.128	354
27	12.33	9.18	10.32	0.126	355
30	12.28	9.17	10.12	0.127	356
33	12.21	9.16	10.16	0.125	356

Table C.53-57 **Water quality measurements taken with a Hydrolab Surveyor II at Gifford, Porcupine Bay, Confluence, Seven Bays, and Spring Canyon in December, 1996.**

Table C.53;

GIFFORD

Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	4.09	8.85	15.00	0.137	345
3		8.92	14.80	0.135	353
6	4.10 4.11	9.00	14.66	0.137	353
9	4.11	9.04	14.59	0.137	353,
12	4.13	9.06	14.55	0.136	352
15	4.14	9.09	14.57	0.136	352
18		9.10	14.49	0.134	352
21	4.11 4.11	9.12	14.44	0.138	352
24	4.14	9.17	14.41	0.135	352
27	4.14	9.15	14.41	0.138	352
30		9.16	14.37	0.134	352
33	4.13 4.13	9.18	14.40	0.137	352

Table C.54;

PORCUPINE BAY

Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0					
3	5.26 5.35	8.92 9.16	13.21 12.68	0.178 0.169	388 331
6	5.35	9.21	13.98	0.183	330
9	5.35	9.23	12.55	0.193	330
12	5.35	9.24	12.44	0.202	329
15	5.35	9.25	12.39	0.176	328
18					
21	5.35 5.35	9.25 9.25	12.36 12.34	0.170 0.174	328 327
24	5.32	9.26	12.33	0.172	326
27	5.35	9.26	12.28	0.174	327
30	5.35	9.26	12.11	0.169	327

Table C.55;

CONFLUENCE					
Depth (m)	**Temp. (°C)**	**pH**	**D.O. (mg/L)**	**Conduct. mmho/cm**	**O R P (mV)**
0	5.35	9.31	13.12	0.062	276
3	5.37	9.33	12.91	0.164	276
6					
9	5.37 5.40	9.34 9.34	13.04 12.96	0.158 0.153	276 276
12	5.40	9.35	12.89	0.162	277
15	5.52	9.34	12.73	0.162	278
18					
21	5.62 5.57	9.33 9.33	12.60 12.51	0.157 0.156	277 278
24	5.60	9.33	12.52	0.180	278
27	5.58	9.33	12.51	0.176	279
30	5.59	9.33	12.46	0.212	280
33	5.62	9.33	12.42	0.147	280

Table C.56;

SEVEN BAYS					
Depth (m)	**Temp. (°C)**	**pH**	**D.O. (mg/L)**	**Conduct. mmho/cm**	**ORP (mV)**
0	4.38	9.30	14.07	0.133	300
3	4.67	9.31	13.87	0.143	301
6	4.74	9.33	13.77	0.142	300
9	4.66	9.35	13.75	0.142	300
12	4.52	9.36	13.82	0.138	300
15	4.59	9.36	13.87	0.138	300
18	4.48	9.37	13.83	0.134	299
21	4.53	9.37	13.84	0.136	300
24	4.48	9.37	13.83	0.137	301
27	4.46	9.37	13.87	0.135	301
30	4.41	9.38	13.92	0.134	301
33	4.37	9.37	13.89	0.134	301

Table C.57;

SPRING CANYON					
Depth (m)	Temp. (°C)	pH	D.O. (mg/L)	Conduct. mmho/cm	ORP (mV)
0	4.57	9.28	14.76	0.105	271
3	4.65	9.32	13.29	0.113	271
6					
9	5.81 5.96	9.31 9.33	13.58 13.27	0.121 0.132	272 272
12	5.94	9.33	13.03	0.131	273
15	6.06	9.33	12.96	0.132	274
18	6.09	9.32	12.93	0.140	275
21	6.16	9.31	12.85	0.133	275
24					
27	6.21 6.17	9.30 9.30	12.79 12.83	0.134 0.133	276 277
30					
33	6.19 6.16	9.30 9.30	12.79 12.72	0.131 0.133	277 278

Table C.58 Monthly secchi disk depths in meters for nine index stations on Lake Roosevelt from March to October, 1996.

	LOCATION								
	1	2	3	4	Confluence	6	7	8	9
Mar	--	4.0	--	0.8	--	1.5	2.5	--	2.3
Apr.	--	2.0	--	0.8	0.8	2.0	2.0	--	2.5
May	1.9	1.9	2.0	0.5	--	3.3	1.1	0.2	3.0
Jun	--	2.7	--	1.7	2.2	3.3	3.7	--	2.7
Jul	4.0	3.7	3.0	4.3	--	4.4	5.8	4.0	5.4
Aug	--	4.4	--	5.8	5.5	5.8	5.6	--	9.4
Sep	--	--	--	5.5	5.8	8.8	11.5	--	7.6
Oct	7.0	8.5	8.0	7.0	--	--	9.0	6.0	8.0
Mean	**4.3**	**3.9**	**4.3**	**3.3**	**3.6**	**4.2**	**5.2**	**3.4**	**5.1**

'--' Indicates no data collected.

APPENDIX D

Creel Survey Data

Table D.1 Correction factor for boat trailers counted by creel to boats counted by air per quarter in 1993.

STRATA		YEAR 1990	1991	1992	1993	1990-1993 MEAN ± STDEV	1992-1993 MEAN ± STDEV
WINTER	Dec-Feb	3.49	1.92	2.01	2.57	2.50 ± 0.72	2.29 ± 0.39
SPRING	Mar-May	3.02	3.74	1.08	1.52	2.34 ± 1.25	1.30 ± 0.31
SUMMER	Jun-Aug	3.71	3.17	1.10	1.01	2.25 ± 1.40	1.06 ± 0.06
FALL	Aug-Nov	1.46	3.13	1.17	1.02	1.70 ± 0.97	1.10 ± 0.11
ANNUAL	Dec-Nov	2.92	2.99	1.34	1.53	2.19 ± 0.88	1.44 ± 0.13

Table D.2 Correction factor for boat trailers counted by creel to boats counted by air in 1993. Split by weekday (WD) and weekend (WE) strata.

STRATA		YEAR 1990	1991	1992	1993	1990-1993 MEAN ± STDEV	1992-1993 MEAN ± STDEV
WINTER	WD	3.90	1.60	1.07	2.14	2.18 ± 1.23	1.61 ± 0.76
	WE	1.84	2.24	2.49	2.85	2.35 ± 0.42	2.67 ± 0.26
SPRING	WD	3.65	5.73	1.50	1.43	3.08 ± 2.05	1.47 ± 0.05
	WE	2.39	1.75	0.77	1.78	1.67 ± 0.67	1.28 ± 0.71
SUMMER	WD	3.37	2.96	1.13	0.66	2.03 ± 1.33	0.90 ± 0.33
	WE	4.12	3.59	1.05	1.35	2.53 ± 1.55	1.20 ± 0.22
FALL	WD	1.53	4.07	1.27	0.87	1.93 ± 1.45	1.07 ± 0.28
	WE	1.41	2.20	1.10	1.33	1.51 ± 0.48	1.22 ± 0.16
ANNUAL	WD	3.11	3.59	1.24	1.28	2.30 ± 1.22	1.26 ± 0.03
	WE	2.44	2.45	1.35	1.83	2.02 ± 0.53	1.59 ± 0.34

Table D.3 Section 1 pressure estimates in hours for boat anglers in 1996 with intermediate calculations.

STRATA		Correct. factor	Mean boat trailers for the day	% of boats fishing	# angler/ boat	# of angler/ boat S.D.	Corrected mean angler	Corrected x angler sd
December	WD	1.60	0.08	100.00	2.00	0.00	0.3	0.0
	WE	2.67	0.20	100.00	2.00	0.00	1.0	0.0
January	WD	1.60	0.00	100.00	2.00	0.00	0.0	0.0
	WE	2.67	0.00	100.00	2.00	0.00	0.0	0.0
February	WD	1.60	0.00	100.00	2.00	0.00	0.0	0.0
	WE	2.67	0.00	100.00	2.00	0.00	0.0	0.0
March	WD	1.46	0.82	87.50	1.33	0.52	1.4	0.5
	WE	1.28	0.75	50.00	2.00	0.00	1.0	0.0
April	WD	1.46	0.74	100.00	2.17	0.98	2.3	1.1
	WE	1.28	0.00	66.67	2.00	0.00	0.0	0.0
May	WD	1.46	0.77	93.75	1.75	0.75	1.8	0.8
	WE	1.28	4.50	100.00	2.00	1.00	11.5	5.8
June	WD	0.90	4.64	92.73	1.96	0.77	7.6	3.0
	WE	1.20	38.88	68.54	2.19	0.83	69.9	26.7
July	WD	0.90	16.94	48.94	2.09	0.70	15.6	5.2
	WE	1.20	82.80	37.04	2.50	1.07	92.0	39.3
August	WD	0.90	9.82	38.46	2.27	0.91	7.7	3.1
	WE	1.20	47.83	8.24	2.33	0.58	11.0	2.7
September	WD	1.07	1.57	85.71	1.50	0.58	2.2	0.8
	WE	1.21	18.43	29.09	2.29	0.49	14.8	3.2
October	WD	1.07	1.06	50.00	1.00	0.00	0.6	0.0
	WE	1.21	3.00	100.00	2.00	0.00	7.3	0.0
November	WD	1.07	0.00	67.86	1.25	0.29	0.0	0.0
	WE	1.21	0.00	64.55	2	0.25	0.0	0.0
Annual	**WD**	**1.26**	**3.04**	**80.41**	**1.78**	**0.46**	**3.3**	**1.2**
	WE	**1.26**	**16.37**	**64.42**	**2.10**	**0.35**	**17.4**	**6.5**

Table D.4 Section 2 pressure estimates for boat anglers in 1996 with intermediate calculations.

STRATA		Correct. factor	Mean boat trailers for the day	% of boats fishing	# angler/boat	# of angler/ boat S.D.	Corrected mean angler	Corrected x angler sd
December	WD	1.60	3.73	100.00	2.00	0.00	11.9	0.0
	WE	2.67	2.00	100.00	1.50	0.71	8.0	3.8
January	WD	1.60	3.00	100.00	1.67	0.52	8.0	2.5
	WE	2.67	9.50	100.00	1.50	0.71	38.0	18.0
February	WD	1.60	2.14	1000.0	1.00	0.00	3.4	0.0
	WE	2.67	5.00	100.00	1.50	0.71	20.0	9.5
March	WD	1.46	3.79	96.15	1.92	0.49	10.2	2.6
	WE	1.28	1.00	98.08	1.96	0.25	2.5	0.3
April	WD	1.46	0.40	100.00	2.00	0.00	1.2	0.0
	WE	1.28	0.59	98.08	1.96	0.25	1.4	0.2
May	WD	1.46	0.00	98.08	1.96	0.25	0.0	0.0
	WE	1.28	0.17	98.08	1.96	0.25	0.4	0.1
June	WD	0.90	30.79	35.77	2.00	0.52	19.8	5.2
	WE	1.20	57.83	14.81	2.00	0.00	20.6	0.0
July	WD	0.90	54.07	33.64	2.27	0.99	37.2	16.1
	WE	1.20	147.50	29.41	4.00	1.41	208.2	73.6
August	WD	0.90	42.29	19.19	2.38	0.52	17.3	3.8
	WE	1.20	90.40	18.42	2.33	1.16	46.6	23.1
September	WD	1.07	8.90	93.75	1.50	0.58	13.4	5.2
	WE	1.21	20.75	100.00	2.29	0.49	57.4	12.3
October	WD	1.07	6.20	100.00	1.89	0.33	12.5	2.2
	WE	1.21	16.75	85.00	2.71	0.95	46.8	16.4
November	WD	1.07	1.11	100.00	2.00	0.00	2.4	0.0
	WE	1.21	3.25	100.00	2.00	0.00	7.9	0.0
Annual	**WD**	**1.26**	**13.03**	**81.38**	**1.88**	**0.35**	**11.5**	**3.1**
	WE	**1.59**	**29.56**	**72.96**	**2.13**	**0.57**	**38.2**	**13.1**

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Table D.5 Section 3 pressure estimates in hours for boat anglers in 1996 with intermediate calculations.

STRATA		Correct. factor	Mean boat trailers for the day	% of boats fishing	# angler/ boat	# angler/ boat S .D.	Corrected mean angler	Corrected x angler sd
December	**WD**	1.60	1.57	100.00	1.69	0.47	4.2	1.2
	WE	2.67	0.83	100.00	1.55	0.57	3.4	1.3
January	**WD**	1.60	0.93	100.00	1.50	0.58	2.2	0.9
	WE	2.67	1.00	100.00	1.50	0.58	4.0	1.5
February	**WD**	1.60	9.18	100.00	1.88	0.35	27.5	5.2
	WE	2.67	8.00	100.00	1.60	0.55	34.2	11.7
March	**WD**	1.46	6.21	100.00	1.75	0.50	15.9	4.5
	WE	1.28	2.50	100.00	2.00	0.00	6.4	0.0
April	**WD**	1.46	4.85	100.00	1.33	0.58	9.4	4.1
	WE	1.28	1.33	100.00	2.00	0.00	3.4	0.0
May	**WD**	1.46	5.00	100.00	1.54	0.54	11.2	3.9
	WE	1.28	40.50	100.00	2.00	0.00	103.7	0.0
June	**WD**	0.90	18.00	100.00	1.79	0.42	28.9	6.8
	WE	1.20	18.00	100.00	2.50	0.71	54.0	15.3
July	**WD**	0.90	87.87	75.00	1.67	0.50	98.9	29.7
	WE	1.20	132.75	50.00	2.50	0.71	199.1	56.3
August	**WD**	0.90	71.87	16.67	2.00	0.00	21.6	0.0
	WE	1.20	97.00	0.00	2.50	0.71	0.0	0.0
September	**WD**	1.07	22.17	60.00	1.50	0.71	21.3	10.1
	WE	1.21	11.20	50.00	1.00	0.00	6.8	0.0
October	**WD**	1.07	6.00	100.00	1.64	0.63	10.5	4.1
	WE	1.21	4.50	50.00	2.00	0.00	5.4	0.0
November	**WD**	1.07	1.93	100.00	1.00	0.00	2.1	0.0
	WE	1.21	1.00	50.00	1.50	0.00	0.9	0.0
Annual	**WD**	**1.26**	**19.63**	**87.64**	**1.61**	**0.44**	**21.2**	**5.9**
	WE	**1.59**	**26.55**	**72.92**	**1.83**	**0.32**	**35.1**	**7.2**

Table D.6 **Section 1 angling pressure estimates (hrs) from December, 1995 to November, 1996 with intermediate calculations.**

STRATA	Hours per day (naut) Hd	Days per month (Cal) Ds	Hours per month Ns	Hours creeled per month n	Time correction factor Ns/n	Angler hours per angler Ha	Mean anglers per day Xd	Mean anglers per month xs	± anglers per day Sd	± anglers per month ss	Pressure estimate per month PE	Variance of pressure estimate per month VPE	95% C.I. per month CI
DECEMBER													
WEEKDAY													
Shore	8.40	20	168.00	48.17	3.49	2.36	2.1	41.6	2.2	43.0	343	6,449	157
Boat	8.40	20	168.00	48.17	3.49	2.50	0.3	5.3	0.0	0.0	46	0	0
WEEKEND													
Shore	8.40	I1	92.40	16.50	5.60	2.85	3.6	39.6	2.3	25.3	632	3,585	117
Boat	8.40	11	92.40	16.50	5.60	3.35	1.1	11.7	0.0	0.0	220	0	0
TOTAL	8.40	**31**	260.40	64.67			7.0	98.3	4.5	68.3	**1,241**	10,034	275
JANUARY													
WEEKDAY													
Shore	8.83	21	185.43	74.50	2.49	2.94	1.6	34.4	1.9	39.1	252	3,797	121
Boat	8.83	21	185.43	74.50	2.49	2.50	0.0	0.0	0.0	0.0	0	0	0
WEEKEND													
Shore	8.83	10	88.30	18.00	4.91	3.82	1.3	13.3	1.5	15.3	249	1,148	66
Boat	8.83	10	88.30	18.00	4.91	3.35	0.0	0.0	0.0	0.0	0	0	0
TOTAL	8.83	31	273.73	92.50			3.0	47.7	3.4	54.4	501	4,946	187
FEBRUARY													
WEEKDAY													
Shore	10.25	19	194.75	61.50	3.17	2.00	1.5	27.7	2.0	37.6	176	4,482	131
Boat	10.25	19	194.75	61.50	3.17	2.50	0.0	0.0	0.0	0.0	0	0	0
WEEKEND													
Shore	10.25	**10**	102.50	18.50	5.54	3.38	1.8	17.5	2.1	20.6	327	2,351	95
Boat	10.25	**10**	102.50	18.50	5.54	3.35	0.0	0.0	0.0	0.0	0	0	0
TOTAL	**10.25**	**29**	297.25	80.00			3.2	45.2	4.0	58.2	503	6,833	226

Table D.6 Continued.

STRATA	Hours per day (naut) Hd	Days per month (Cal) Ds	Hours per month Ns	Hours creeled per month n	Time correction factor Ns/n	Angler hours per angler Ha	Mean anglers per day Xd	Mean anglers per month xs	+/- anglers per day. Sd	+/- anglers per month ss	Pressure estimate per month PE	Variance of pressure estimate per month VPE	95% C.I. per month CI
MARCH													
WEEKDAY													
Shore	II.97	21	251.37	84.85	2.96	2.31	1.5	30.9	1.3	27.9	211	2,311	94
Boat	11.97	21	251.37	84.85	2.96	5.24	1.4	29.5	0.5	10.5	457	327	35
WEEKEND													
Shore	11.97	10	119.70	20.00	5.99	4.67	1.3	0.0	1.0	9.6	0	552	46
Boat	II.97	10	119.70	20.00	5.99	2.68	1.0	9.6	0.0	0.0	154	0	0
TOTAL	11.97	31	371.07	104.85			5.1	69.9	2.8	48.0	822	3,189	176
APRIL													
WEEKDAY													
Shore	13.68	22	300.96	96.00	3.14	2.83	0.3	7.0	0.8	18.0	63	1,020	63
Boat	13.68	22	300.96	96.00	3.14	5.47	2.3	51.3	1.1	24.2	879	1,836	84
WEEKEND													
Shore	13.68	8	109.44	15.00	7.30	4.67	0.0	0.0	0.0	0.0	0	0	0
Boat	13.68	8	109.44	15.00	7.30	1.78	0.0	0.0	0.0	0.0	0	0	0
TOTAL	13.68	30	410.40	111.00			2.7	58.3	1.9	42.2	941	2,856	147
MAY													
WEEKDAY													
Shore	15.20	22	334.40	86.00	3.89	3.75	0.1	2.6	0.5	10.8	38	452	42
Boat	15.20	22	334.40	86.00	3.89	5.36	1.8	40.3	0.8	17.6	840	1,204	68
WEEKEND													
Shore	15.20	9	136.80	16.00	8.55	4.67	0.5	4.5	1.0	9.0	180	693	52
Boat	15.20	9	136.80	16.00	8.55	4.55	Il.5	103.7	5.8	52.2	4,036	23,297	299
TOTAL	15.20	31	471.20	102.00			14.0	151.1	281	89.6	5,094	25,646	460
JUNE													
WEEKDAY													
Shore	16.02	20	320.40	87.00	3.68	4.13	0.0	0.0	0.0	0.0	0	0	0
Boat	16.02	20	320.40	87.00	3.68	6.58	7.6	152.0	3.0	60.0	3,683	13,258	226
WEEKEND													
Shore	16.02	10	160.20	41.17	3.89	10.75	0.0	0.0	0.0	0.0	0	0	0
Boat	16.02	10	160.20	41.17	3.89	6.46	69.9	698.6	26.7	267.0	17,557	277.419	1,032
TOTAL	16.02	30	480.60	128.17			77.5	850.7	29.7	327.0	21,241	290,677	1,258

Table D.6 Continued.

STRATA	Hours per day (naut) Hd	Days per month (cal) Ds	Hours per month Ns	Hours creeied per month n	Time correction factor Ns/n	Angler hours per angler Ha	Mean anglers per day Xd	Mean anglers per month xs	± anglers per day Sd	± anglers per month ss	Pressure estimate per month PE	Variance of pressure estimate per month VPE	95% C.I. per month CI
JULY													
WEEKDAY													
Shore	15.67	22	344.74	101.00	3.41	4.13	0.1	2.4	0.5	10.3	34	365	37
Boat	15.67	22	344.74	101 .00	3.41	6.34	15.6	343.3	5.2	114.4	7,425	44,671	414
WEEKEND													
Shore	15.67	9	141.03	26.00	5.42	10.75	0.0	0.0	0.0	0.0	0	0	0
Boat	15.67	9	141.03	26.00	5.42	8.40	92.0	828.1	39.3	353.7	37,716	678,591	1,615
TOTAL	15.67	31	485.77	127.00			107.7	1173.8	45.0	478.4	45,175	723,627	2,066
AUGUST													
WEEKDAY													
Shore	14.38	22	316.36	90.00	3.52	4.13	0.4	7.7	1.0	22.0	112	1,701	81
Boat	14.38	22	316.36	90.00	3.52	6.56	7.7	170.0	3.1	68.2	3,919	16,350	251
WEEKEND													
Shore	14.38	9	129.42	30.00	4.31	10.75	1.3	12.0	2.1	18.6	555	1,497	76
Boat	14.38	9	129.42	30.00	4.31	5.91	0.0	0.0	2.7	24.3	0	2,547	99
TOTAL	14.38	31	445.78	120.00			9.4	189.7	8.9	133.1	4,585	22,096	506
SEPTEMBER													
WEEKDAY													
Shore	12.45	20	249.00	69.00	3.61	2.71	0.0	0.0	0.0	0.0	0	0	0
Boat	12.45	20	249.00	69.00	3.61	5.38	2.2	43.2	0.8	16.0	840	924	60
WEEKEND													
Shore	12.45	10	li4.50	35.00	3.56	7.92	0.0	0.0	0.0	0.0	0	0	0
Boat	12.45	10	124.50	35.00	3.56	5.95	14.8	148.3	3.2	32.0	3,138	3,643	118
TOTAL	12.45	30	373.50	104.00			17.0	191.5	220	48.0	3,977	4,566	178
OCTOBER													
WEEKDAY													
Shore	10.73	22	236.06	85.00	2.78	2.71	0.0	0.0	0.0	0.0	0	0	0
Boat	10.73	22	236.06	85.00	2.78	6.78	0.6	12.5	0.0	0.0	235	0	0
WEEKEND													
Shore	10.73	9	96.57	15.00	6.44	7.92	0.0	0.0	0.0	0.0	0	0	0
Boat	10.73	9	96.57	15.00	6.44	2.18	7.3	65.3	0.0	0.0	918	0	0
TOTAL	10.73	31	332.63	100.00			7.8	77.8	0.0	0.0	1,153	0	0

Table D.6 Continued.

STRATA	Hours per day (naut) Hd.	Days per month (Ca) Ds	Hours per month Ns	Hours creeled per month n	Time correction factor Nsln	Angler hours per angler Ha	Mean anglers per day Xd	Mean anglers per month xs	+/- anglers per day Sd	+/- anglers per month ss	Pressure estimate per month PE	Variance of pressure estimate per month VPE	95% C.I. per month CI
NOVEMBER													
WEEKDAY													
Shore	9.20	20	184.00	60.00	3.07	2.71	0.4	8.4	0.5	10.2	70	319	35
Boat	9.20	20	184.00	60.00	3.07	6.08	0.0	0.0	0.0	0.0	0	0	0
WEEKEND													
Shore	9.20	10	92.00	10.00	9.20	7.92	1.0	10.0	1.0	10.0	729	920	59
Boat	9.20	10	92.00	10.00	9.20	4.07	0.0	0.0	0.0	0.0	0	0	0
TOTAL	9.20	30	276.00	70.00			1.4	18.4	1.5	20.2	798	1,239	94
ANNUAL TOTAL	146.78	366.00	4,478.3	1,204.2			255.7	2,972.5	113.7	1,36.7.5	86,032	1,095,708	5,574

Table D.7 Section 2 angling pressure estimates (hrs) from December, 1995 to November, 1996 with intermediate calculations.

STRATA	Hours per day (naut) Hd	Days per month (cd) Ds	Hours per month Ns	Hours creeled per month n	Time correction factor Nsln	Angler hours per angler Ha	Mean anglers per day Xd	Mean anglers per month xs	+/- anglers per day Sd	+/- anglers per month ss	Pressure estimate per month PE	Variance of pressure estimate per month VPE	95% C.I. per month CI
DECEMBER													
WEEKDAY													
Shore	8.40	20	168.00	45.07	3.73	4.00	0.5	9.0	1.0	20.8	134	1,613	79
Boat	8.40	20	168.00	45.07	3.73	4.28	11.9	238.0	0.0	0.0	3,795	0	0
WEEKEND													
Shore	8.40	11	92.40	13.63	6.78	4.25	2.4	26.4	2.3	25.3	760	4,338	129
Boat	8.40	11	92.40	13.63	6.78	4.67	8.0	88.0	3.8	41.8	2,784	11,842	213
TOTAL	8.40	**31**	260.40	58.70			22.8	361.4	7.1	87.9	7,474	**17,793**	421
JANUARY													
WEEKDAY													
Shore	8.83	21	185.43	36.58	5.07	4.50	5.4	114.0	4.1	86.5	2,601	37,943	382
Boat	8.83	21	185.43	36.58	5.07	4.31	8.0	168.0	2.5	52.5	3,666	13,971	232
WEEKEND													
Shore	8.83	10	88.30	3.00	29.43	4.25	13.5	135.0	9.2	91.9	16,887	248,582	977
Boat	8.83	10	88.30	3.00	29.43	4.67	38.0	380.0	18.0	180.0	52,232	953,640	1,914
TOTAL	8.83	**31**	273.73	39.58			64.9	797.0	33.8	**410.9**	75,387	**1,254,136**	3,505
FEBRUARY													
WEEKDAY													
Shore	10.25	19	194.75	24.13	8.07	3.69	4.3	81.5	5.1	97.3	2,430	76,368	542
Boat	10.25	19	194.75	24.13	8.07	7.25	3.4	64.6	0.0	0.0	3,780	0	0
WEEKEND													
Shore	10.25	10	102.50	10.00	10.25	4.25	14.7	146.7	8.5	85.0	6,388	74,056	533
Boat	10.25	10	102.50	10.00	10.25	4.67	20.0	200.0	9.5	95.0	9,574	92,506	596
TOTAL	**10.25**	**29**	297.25	34.13			42.4	492.8	23.1	277.3	22,170	242,931	1,671

Table D.7 continued

STRATA	Hours per day (naut) Hd	Days per month (cal) Ds	Hours per month Ns	Hours creeled per month n	Time correction factor Ns/n	Angler hours per angler Ha	Mean anglers per day Xd	Mean anglers per month Xs	± anglers per day Sd	± Pressure anglers per month Ss	Variance estimate per month PE	O r pressure estimate per month VPE	95% C.I. per month CI
MARCH													
WEEKDAY													
Shore	11.97	21	251.37	66.18	3.80	3.69	1.6	33.0	1.3	26.9	462	2,744	103
Boat	11.97	21	251.37	66.18	3.80	5.44	10.2	214.2	2.6	54.6	4,427	11,323	209
WEEKEND													
Shore	11.97	10	119.70	7.97	15.02	5.68	3.5	0.0	5.0	49.5	0	36,814	376
Boat	11.97	10	119.70	7.97	15.02	5.44	2.5	25.0	0.3	3.0	2,043	135	23
TOTAL	**11.97**	**31**	**371.07**	**74.15**			**17.8**	**272.2**	**9.1**	**134.0**	**6,932**	**51,016**	**710**
APRIL													
WEEKDAY													
Shore	13.68	22	300.96	20.08	14.99	3.69	0.0	0.0	0.0	0.0	0	0	0
Boat	13.68	22	300.96	20.08	14.99	5.00	1.2	26.4	0.0	0.0	1,978	0	0
WEEKEND													
Shore	13.68	8	1 09-M	11.05	9.90	5.68	2.0	16.0	3.1	24.8	900	6,091	153
Boat	13.68	8	109.44	11.05	9.90	5.44	1.4	11.2	0.2	1.6	603	25	10
TOTAL	**13.68**	**30**	**410.40**	**31.13**			**4.6**	**53.6**	**3.3**	**26.4**	**3,482**	**6,117**	**163**
MAY													
WEEKDAY													
Shore	15.20	22	334.40	44.78	7.47	3.69	0.0	0.0	0.0	0.0	0	0	0
Boat	15.20	22	334.40	44.78	7.47	5.22	0.0	0.0	0.0	0.0	0	0	0
WEEKEND													
Shore	15.20	9	136.80	3.08	44.37	5.68	0.5	4.5	1.2	11.0	1,134	5,350	143
Boat	15.20	9	136.80	3.08	44.37	5.44	0.4	3.6	0.1	0.9	869	36	12
TOTAL	**15.20**	**31**	**471.20**	**47.87**			**0.9**	**8.1**	**1.3**	**11.9**	**2,003**	**5,385**	**155**
JUNE													
WEEKDAY													
Shore	16.02	20	320.40	55.63	5.76	2.04	0.0	0.0	0.0	0.0	0	0	0
Boat	16.02	20	320.40	55.63	5.76	4.31	19.8	396.0	5.2	104.0	9,832	62,291	489
WEEKEND													
Shore	16.02	10	160.20	25.53	6.27	3.50	0.0	0.0	0.0	0.0	0	0	0
Boat	16.02	10	160.20	25.53	6.27	5.83	20.6	206.0	0.0	0.0	7,534	0	0
TOTAL	**16.02**	**30**	**480.60**	**81.17**			**40.4**	**602.0**	**5.2**	**104.0**	**17,366**	**62,291**	**489**

Table D.7 Continued.

STRATA	Hours per day (naut) Hd	Days per month (cal) Ds	Hours per month Ns	Hours creeled per month n	Time correction factor Ns/n	Angler hours per angler Ha	Mean. anglers per day Xd	Mean anglers per month xs	+/- anglers per day Sd	+/- anglers per month ss	Pressure estimate per month PE	Variance of pressure estimate per month VPE	95% C.I. per month Cl
JULY													
WEEKDAY													
Shore	15.67	22	344.74	61.80	5.58	I .oo	2.1	47. I	2.8	61.6	263	21,167	285
Boat	15.67	22	344.74	61.80	5.58	4.33	37.2	818.4	16.1	354.2	19,777	699,843	1,640
WEEKEND													
Shore	15.67	9	141.03	8.07	17.48	3.50	2.5	22.5	3.5	31.9	1,377	**17,746**	261
Boat	15.67	9	141.03	8.07	17.48	4.76	208.2	1873.8	73.6	662.4	155,930	7,670,790	5,428
TOTAL	15.67	31	485.77	69.87			250.0	2761.8	96.0	**1110.1**	**177,346**	8,409,545	7,614
AUGUST													
WEEKDAY													
Shore	14.38	22	316.36	78.38	4.04	3.08	0.1	2.6	0.5	10.8	33	469	42
Boat	14.38	22	316.36	78.38	4.04	3.83	17.3	380.6	3.8	83.6	5,886	28,208	329
WEEKEND													
Shore	14.38	9	129.42	20.57	6.29	3.50	0.6	5.4	1.3	12.1	119	915	59
Boat	14.38	9	129.42	20.57	6.29	5.36	46.6	419.4	23.1	207.9	14,138	271,982	1,022
TOTAL	14.38	31	445.78	98.95			64.6	808.0	28.7	314.3	20,176	301,574	1,453
SEPTEMBER													
WEEKDAY													
Shore	12.45	20	249.00	40.10	6:21	1.88	0.2	4.0	0.6	12.6	47	986	62
Boat	12.45	20	249.00	40. IO	6.21	4.65	13.4	268.0	5.2	104.0	7,743	67.162	508
WEEKEND													
Shore	12.45	**IO**	124.50	15.12	8.24	4.00	1.3	12.5	1.5	15.0	412	1,853	84
Boat	12.45	IO	124.50	15.12	8.24	4.51	57.4	574.0	12.3	123.0	21,334	124,599	692
TOTAL	12.45	30	373.50	55.22			72.3	858.5	**1916**	254.6	29,536	**194,599**	1,346
OCTOBER													
WEEKDAY													
Shore	IO.73	22	236.06	49.85	4.74	1.88	0.5	11.7	1.1	23.3	104	2,575	99
Boat	10.73	22	236.06	49.85	4.74	3.90	12.5	275.0	2.2	48.4	5,083	I 1,093	206
WEEKEND													
Shore	10.73	9	96.57	15.80	6.11	4.00	1.5	13.5	1.0	9.0	330	495	44
Boat	10.73	9	96.57	15.80	6.11	4.00	46.8	421.2	16.4	147.6	10,298	133,155	715
TOTAL	**10.73**	**31**	332.63	65.65			61.3	721.4	20.7	228.3	15,814	147,318	1,065

. **Table D.7 Continued.**

STRATA	Hours per day (naut) Hd	Days per month (Cal) Ds	Hours per month Ns	Hours creeled per month n	Time correction factor Ns/n	Angler hours per angler Ha	Mean anglers per day Xd	Mean anglers per month xs	± anglers per day Sd	± anglers per month ss	Pressure estimate per month PE	Variance of pressure estimate per month VPE	95% C.I. per month Cl
NOVEMBER													
WEEKDAY													
Shore	9.20	20	184.00	25.60	7.19	1.88	0.3	6.6	0.7	14.2	89	1,449	75
Boat	9.20	20	184.00	25.60	7.19	4.25	2.4	48.0	0.0	0.0	1,466	0	0
WEEKEND													
Shore	9.20	IO	92.00	15.10	6.09	4.00	1.8	17.5	1.5	15.0	426	1,371	73
Boat	9.20	IO	92.00	15.10	6.09	3.25	7.9	79.0	0.0	0.0	1,564	0	0
TOTAL	9.20	30	276.00	40.70			12.4	151.1	2.2	29.2	3,54	2,820	147
ANNUAL TOTAL	146.78	366.00	4478.33	697.12			654.3	7887.9	250.3	2988.9	381,232	10,695,527	18,739

Table D.8 Section 3 angling pressure estimates (hrs) from December, 1995 to November, 1996 with intermediate calculations.

STRATA	Hours per day (naut) Hd	Days per month (cal) Ds	Hours per month Ns	Hours creeled per month n	Time correction factor Ns/n	Angler hours per angler Ha	Mean anglers per day Xd	Mean anglers per month xs	± anglers per day Sd	± anglers per month ss	Pressure estimate per month PE	Variance of pressure estimate per month VPE	95% C.I. per month CI
DECEMBER													
WEEKDAY													
Shore	8.40	20	168.00	40.42	4.16	7.44	1.4	27.2	2.1	41.2	841	7,056	165
Boat	8.40	20	168.00	40.42	4.16	6.32	4.2	84.0	1.2	24.0	2,207	2,394	96
WEEKEND													
Shore	8.40	11	92.40	18.25	5.06	1.29	2.3	25.6	4.3	47.5	167	I 1,433	210
Boat	8.40	11	92.40	18.25	5.06	6.68	3.4	37.4	1.3	14.3	I.265	**1,035**	63
TOTAL	8.40	31	260.40	58.67			**11.3**	174.2	8.9	127.0	4,480	**21,918**	533
JANUARY													
WEEKDAY													
Shore	8.83	21	185.43	50.00	3.71	4.17	3.0	63.0	1.6	33.0	974	4,03 I	124
Boat	8.83	21	185.43	50.00	3.71	5.86	2.2	46.2	0.9	18.9	1,004	1,325	71
WEEKEND													
Shore	8.83	IO	88.30	14.50	6.09	2.50	3.8	37.5	2.6	26.3	571	4,212	127
Boat	8.83	IO	88.30	14.50	6.09	6.93	4.0	40.0	1.5	15.0	1,688	1,370	73
TOTAL	8.83	31	273.73	64.50			13.0	186.7	6.6	93.2	4,237	**10,938**	396
FEBRUARY													
WEEKDAY													
Shore	10.25	19	194.75	42.67	4.56	4.78	6.6	124.5	6.9	131.1	2,714	78,450	549
Boat	10.25	I9	194.75	42.67	4.56	6.77	27.5	522.5	5.2	98.8	16,151	44,555	414
WEEKEND													
Shore	/IO.25	IO	102.50	15.75	6.51	2.08	4.3	42.5	5.0	49.9	576	16,205	250
Boat	10.25	IO	102.50	15.75	6.51	6.42	34.2	342.0	Il.7	117.0	14,282	89,087	585
TOTAL	**10.25**	**29**	297.25	58.42			72.5	**1031.5**	28.8	396.8	33,723	228,297	1,797

Table D.8 Continued.

STRATA	Hours per day (naut) Hd	Days per month (Cal) Ds	Hours per month Ns	Hours creeled per month n	Time correction factor Nsln	Angler hours per angler Ha	Mean anglers per day Xd	Mean anglers per month xs	+/- anglers per day Sd	+/- anglers per month ss	Pressure estimate per month PE	Variance of pressure estimate per month VPE	95% C.I. per month Cl
MARCH													
WEEKDAY													
Shore	I I .97	21	251.37	53.50	4.70	2.17	5.2	109.4	4.2	88.0	1,116	36,377	3-74
Boat	11.97	21	251.37	53.50	4.70	7.08	15.9	333.9	4.5	94.5	11,112	41,959	401
WEEKEND													
Shore	11.97	10	119.70	17.50	6.84	2.17	2.5	0.0	3.0	30.0	0	6,156	154
Boat	I I .97	10	119.70	17.50	6.84	5.53	6.4	64.0	0.0	0.0	2,420	0	0
TOTAL	11.97	31	371.07	71.00			30.0	507.3	11.7	212.5	14,647	84,492	929
APRIL													
WEEKDAY													
Shore	13.68	22	300.96	51.42	5.85	2.17	1.2	25.3	1.1	25.1	321	3,682	119
Boat	13.68	22	300.96	51.42	5.85	5.77	9.4	206.8	4.1	90.2	6,986	47,623	428
WEEKEND													
Shore	13.68	8	109.44	10.00	10.94	2.17	0.5	4.0	0.7	5.7	95	353	37
Boat	13.68	8	109.44	10.00	10.94		3.4	27.2	0.0	0.0	0	0	0
TOTAL	13.68	30	410.40	61.42			14.5	263.3	6.0	121.0	7,402	51,658	583
MAY													
WEEKDAY													
Shore	15.20	22	334.40	51.92	6.44	2.17	1.1	24.6	0.9	18.9	344	2,306	94
Boat	15.20	22	334.40	51.92	6.44	6.43	11.2	246.4	3.9	85.8	10,205	47,417	427
WEEKEND													
Shore	15.20	9	136.80	16.50	8.29	2.17	2.3	20.3	1.9	17.0	364	2,399	96
Boat	15.20	9	136.80	16.50	8.29	6.36	103.7	933.3	0.0	0.0	49,190		0
TOTAL	15.20	31	471.20	68.42			118.3	1,224.6	6.7	121.7	60,103	52,!21	617
JUNE													
WEEKDAY													
Shore	16.02	20	320.40	55.17	5.81	2.17	0.5	10.0	0.8	15.2	126	1,342	72
Boat	16.02	20	320.40	55.17	5.81	6.87	10.3	206.0	2.4	48.0	8,213	13,381	227
WEEKEND													
Shore	16.02	IO	160.20	18.25	8.78	2.17	0.5	5.0	0.6	5.8	95	295	34
Boat	16.02	10	160.20	18.25	8.78	6.40	8.0	80.0	2.3	23.0	4,494	4,644	134
TOTAL	16.02	30	480.60	73.42			19.3	301.0	6.0	92.0	12,929	19,662	466

Table DA Continued.

STRATA	Hours per day (naut) Hd	Days per month (cal) Ds	Hours per month Ns	Hours creeled per month n	Time correction factor Nsln	Angler hours per angler Ha	Mean anglers per day Xd	Mean anglers per month xs	± anglers per day Sd	± anglers per month ss	Pressure estimate per month PE	Variance of pressure estimate per month VPE	95% C.I. per month CI
JULY													
WEEKDAY													
Shore	15.67	22	344.74	54.50	6.33	2.17	2.3	51.3	2.7	60.3	704	22,985	297
Boat	15.67	22	344.74	54.50	6.33	9.84	44.3	974.6	13.3	292.6	60,650	541,557	1,442
. WEEKEND													
Shore	15.67	9	141.03	16.17	8.72	2.17	1.8	15.8	2.4	21.2	298	3,935	123
Boat	IS.67	9	141.03	16.17	8.72	6.40	117.1	1,053.9	33.1	297.9	58,838	774,146	1,725
TOTAL	15.67	31	485.77	70.67			165.5	2,095.S	51.5	672.0	120,490	1,342,623	3,587
AUGUST													
WEEKDAY													
Shore	14.38	22	316.36	61.42	5.15	2.17	0.5	10.3	1.0	21.8	116	2,443	97
Boat	14.38	22	316.36	61.42	5.15	6.08	21.6	475.2	0.0	0.0	14,890	0	0
WEEKEND													
Shore	14.38	9	129.42	19.25	6.72	2.17	1.4	12.6	1.3	12.1	184	978	61
Boat	14.38	9	129.42	19.25	6.72	6.40	0.0	0.0	0.0	0.0	0	0	0
TOTAL	14.38	31	445.78	80.67			23.5	498.1	2.3	33.8	15,189	3,421	158
SEPTEMBER													
WEEKDAY													
Shore	12.45	20	249.00	43.00	5.79	7.44	0.0	0.0	0.0	0.0	0	0	0
Boat	12.45	20	249.00	43.00	5.79	8.44	21.3	426.0	10.1	202.0	20,830	236,284	953
WEEKEND													
Shore	12.45	10	124.50	21.50	5.79	1.29	0.0	0.0	0.0	0.0	0	0	0
Boat	12.45	10	124.50	21.50	5.79	6.17	6.8	68.0	0.0	0.0	2,430	0	0
TOTAL	12.45	30	373.50	64.50			28.1	494.0	10.1	202.0	23,260	236,284	953
OCTOBER													
WEEKDAY													
Shore	10.73	22	236.06	47.83	4.94	7.44	0.3	7.3	0.7	14.3	267	1,009	62
Boat	10.73	22	236.06	47.83	4.94	7.25	10.5	231.0	4.1	90.2	8,270	40,152	393
WEEKEND													
Shore	10.73	9	‘96.57	16.17	5.97	1.29	0.5	4.5	1.0	9.0	35	484	43
Boat	10.73	9	96.57	16.17	5.97	6.17	5.4	48.6	0.0	0.0	1,790	0	0
TOTAL	10.73	31	332.63	64.00			16.7	291.4	5.8	113.5	10,361	41,645	498

Table D.8 Continued.

STRATA	Hours per day (naut) Hd	Days per month (cal) Ds	Hours per month Ns	Hours creeled per month n	Time/ correction factor Nsln	Angler hours per angler Ha	Mean anglers per day Xd	Mean anglers per month xs	+/- anglers per day Sd	+/- anglers per month ss	Pressure estimate per month PE	Variance of pressure estimate per month VPE	95% C.I. per month CI
NOVEMBER													
WEEKDAY													
Shore	9.20	20	184.00	53.92	3.41	7.44	0.1	I .4	0.3	5.4	36	100	20
Boat	9.20	20	184.00	53.92	3.41	3.58	2.1	42.0	0.0	0.0	514	0	0
WEEKEND													
Shore	9.20	10	92.00	24.17	3.81	1.29	0.3	3.3	0.8	8.2	16	256	31
Boat	9.20	10	92.00	24.17	3.81	6.17	0.9	9.0	0.0	0.0	211	0	0
TOTAL	9.20	30	276.00	78.08			3.4	55.7	1.1	13.6	777	355	51
ANNUAL TOTAL	146.78	366.00	4478.33	813.75			717.2	9,894.S	202.4	2986.7	464,226	6,012,821	14,726

Table D.9 **Section 1 harvest per unit effort (fish kept/hour) in Lake Roosevelt from December, 1995 through November, 1996.**

Species	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	Annual Mean
kokanee salmon	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
rainbow trout	0.000	0.065	0.053	0.000	0.000	0.000	0.003	0.032	0.008	0.000	0.000	0.148	0.011
walleye	0.117	0.000	0.000	0.019	0.181	0.569	0.471	0.446	0.131	0.052	0.000	0.000	0.331
smallmouth bass	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.004	0.000	0.000	0.000	0.002
sturgeon	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
other species*	0.000	0.000	0.000	0.019	0.013	0.000	0.013	0.000	0.000	0.000	0.000	0.000	0.007
Monthly Mean	**0.117**	**0.065**	**0.053**	**0.038**	**0.194**	**0.569**	**0.489**	**0.478**	**0.143**	**0.052**	**0.000**	**0.148**	**0.351**

*Includes yellow perch, largemouth bass, suckers, squawfish, black crappie, chinook, bullhead, etc...

Table D.10 Section 2 harvest per unit effort (fish kept/hour) in Lake Roosevelt from December, 1995 through November, 1996.

Snecies	DEC	JAN	FEB	MAR	APR	MAY	.TUN	.TUL	AUG	SEP	OCT	NOV	Annual Mean
kokanee	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
rainbow trout	0.000	0.000	0.I75	0.009	0.000	0.000	0.000	0.000	0.000	0,000	0.043	0.000	0.011
walleye	0.000	0.000	0.000	0.000	0.000	0.000	0.034	0.380	0.000	0.000	0.000	0.000	0.042
smallmouth bass	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
sturgeon	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
other species*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Monthly Mean	**0.000**	**0.000**	**0.175**	**0.009**	**0.000**	**0.000**	**0.034**	**0.380**	**0.000**	**0.000**	**0.043**	**0.000**	**0.054**

*Includes yellow perch, largemouth bass, suckers, squawtish, black crappie, chinook, bullhead, etc...

Table D.ll Section 3 harvest per unit effort (fish kept/hour) in Lake Roosevelt from December, 1995 through November, 1996.

Species	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	Annual Mean
kokanee	0.000	0.173	0.000	0.036	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.020
rainbow trout	0.329	0.338	0.307	0.447	0.437	0.000	0.197	0.364	0.356	0.039	0.330	0.559	0.278
walleye	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.007	0.000	0.039	0.000	0.000	0.004
smallmouth bass	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
sturgeon	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
other species*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Monthly Mean	**0.329**	**0.511**	**0.307**	**0.483**	**0.437**	**0.000**	**0.205**	**0.372**	**0.356**	**0.07**	**0.330**	**0.559**	**0.302**

*Includes yellow perch, largemouth bass, suckers, squawfish, black crappie, chinook, bullhead, etc...

Table D.12 Section 1 catch per unit effort (fish/hour - harvest and release) in Lake Roosevelt from December, 1995 through November, 1996.

Species	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	Annual Mean
kokanee	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
rainbow trout	0.000	0.065	0.053	0.000	0.000	0.000	0.003	0.032	0.008	0.007	0.000	0.148	0.012
walleye	0.117	0.000	0.000	0.019	0.181	0.931	0.861	0.963	0.210	0.052	0.000	0.000	0.615
smallmouth bass	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.004	0.000	0.000	0.000	0.002
sturgeon	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
other species*	0.000	0.000	0.000	0.019	0.026	0.026	0.014	0.003	0.000	0.000	0.000	0.000	0.009
Monthly Mean	**0.117**	**0.065**	**0.053**	**0.038**	**0.207**	**0.957**	**0.881**	**0.998**	**0.222**	**0.05**	**0.000**	**0.148**	**0.638**

*Includes yellow perch, largemouth bass, suckers, squawfish, black crappie, chinook, bullhead, etc...

Table D.13 Section 2 catch per unit effort (fish/hour - harvest and release) in Lake Roosevelt from December, 1995 through November, 1996.

Species	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	Annual Mean
kokanee	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.000**
rainbow trout	0.000	0.000	0.175	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.043	0.000	**0.011**
walleye	0.000	0.000	0.000	0.000	0.000	0.000	0.034	0.407	0.000	0.000	0.000	0.000	**0.045**
smallmouth bass	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.027	0.000	0.000	0.000	0.000	**0.003**
sturgeon	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.000**
other species*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.000**
Monthly Mean	**0.000**	**0.000**	**0.175**	**0.009**	**0.000**	**0.000**	**0.034**	**0.434**	**0.000**	**0.000**	**0.043**	**0.000**	**0.059**

*Includes yellow perch, largemouth bass, suckers, squawfish, black crappie, chinook, bullhead, etc...

Table D.14 Section 3 catch per unit effort (fish/hour - harvest and release) in Lake Roosevelt from December, 1995, through November, 1996.

Species	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	Annual Mean
kokanee	0.000	0.173	0.000	0.036	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.020
rainbow trout	0.329	0.338	0.307	0.447	0.437	0.000	0.205	0.364	0.356	0.039	0.330	0.559	0.280
walleye	0.000	0.000	0.000	0.000	0.000	0.000	0.021	0.007	0.000	0.039	0.000	0.000	0.008
smallmouthbass	0.000	0.000	0.000	0.000	0.000	0.000	0.509	0.000	0.000	0.000	0.000	0.000	0.158
sturgeon	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
other species*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Monthly Mean	**0.32**	**0.511**	**0.307**	**0.483**	**0.437**	**0.000**	**0.73**	**0.372**	**0.354**	**0.079**	**0.330**	**0.559**	**0.467**

*Includes yellow perch, largemouth bass, suckers, squawfish, black crappie, chinook, bullhead, etc...

Table D.15 Total monthly and annual harvest estimates with f 95% confidence intervals from fish harvested by anglers on all sections of Lake Roosevelt from December, 1995 through November, 1996.

SPECIES	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	TOTAL
kokanee	0 *to	734 *69	0 &O	531 *34	0 *O	0 L-0	0 ItO	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	1,265 ±102
rainbow trout	1,473 +/-175	1,466 +/-146	5,049 +/-856	6,614 +/-422	3,237 /-255	0 ±0	2,611 ±96	45,313 ±1,372	5,446 ±60	918 ±38	4,103 ±210	552 ±42	76,782 ±3,672
walleye	146 ±32	0 ±0	0 ±0	15 ±3	170 ±27	2,900 ±262	10,683 ±612	88,417 ±3,841	600 ±66	1,124 ±47	0 ±0	0 ±0	104,055 ±4,852
smallmouth bass	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	61 ±4	0 ±0	18 ±2	0 ±0	0 ±0	0 ±0	79 ± 6
sturgeon	0 +/-O	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 +/-O	0 ±0	0 ±0	0 ±0	0 ± 0
other species*	0 ±0	0 ±0	0 ±0	15 ±3	12 ±2	0 ±0	273 ±16	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	301 ±21
Monthly Total	**1,619 ±207**	**2,200 ±215**	**5,049 ±856**	**7,160 ±459**	**3,407 ±282**	**2,900 ±262**	**13,628 ±728**	**133,730 ±5,213**	**6,064 ±128**	**2,042 ±85**	**4,103 ±210**	**552 ±42**	**182,482 ±8,691**

*Includes yellow perch, largemouth bass, suckers, squawfish, black crappie, chinook, bullhead, etc...

Table D.16 Monthly and annual harvest estimates ± 95% confidence intervals for all fish species surveyed in Section 1 of Lake Roosevelt from December, 1995 through November, 1996.

SPECIES	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	TOTAL
kokanee	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ± 0
rainbow trout	0 ±0	33 ±12	26 ±12	0 ±0	0 ±0	0 ±0	61 ±4	1,440 ±66	36 ±4	0 ±0	0 ±0	118 ±14	1,714 ±111
walleye	146 ±32	0 ±0	0 ±0	15 ±3	170 ±27	2,900 ±262	9,997 ±592	20,163 ±922	600 ±66	206 ±9	0 ±0	0 ±0	34,196 ±1,914
smallmouth bass	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	61 ±4	0 ±0	18 ±2	0 ±0	0 ±0	0 ±0	79 ± 6
sturgeon	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ± 0
other species*	0 ±0	0 ±0	0 ±0	15 ±3	12 ±2	0 ±0	273 ±16	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	301 ±21
Monthly Total	**146 ±32**	**33 ±12**	**26 ±12**	**31 ±7**	**182 ±28**	**2,900 ±262**	**10,392 ±615**	**21,603 ±988**	**654 ±72**	**206 ±9**	**0 ±0**	**118 ±14**	**36,290 ±2,052**

*Includes yellow perch, largemouth bass, suckers, squawfish. black crappie, chinook, bullhead, etc...

Table D.17 Monthly and annual harvest estimates ± 95% confidence intervals for all fish species surveyed in Section 2 of Lake Roosevelt from December, 1995 through November, 1996.

SPECIES	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	TOTAL
kokanee	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 /-O
rainbow trout	0 ±0	0 ±0	3,881 ±293	65 ±7	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	682 ±46	0 ±0	4,628 ±345
walleye	0 ±0	0 ±0	0 ±0	0* ±0	0 ±0	0 ±0	583 ±16	67,359 ±2,892	0 ±0	0 ±0	0 ±0	0 ±0	67,942 ±2,908
smallmouth bass	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 +/-O
sturgeon	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ± 0
other species*	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ± 0
Monthly Total	**0 ± 0**	**0 ± 0**	**3,881 ±293**	**65 ± 7**	**0 ± 0**	**0 ± 0**	583 **±16**	67,359 **±2,892**	0 **± 0**	0 **± 0**	682 **±46**	0 **± 0**	72,569 **±3,253**

*Includes yellow perch, largemouth bass, suckers, squawfish, black crappie, chinook, bullhead, etc...

Table D.18 Monthly and annual harvest estimates ± 95% confidence intervals for all fish species surveyed in Section 3 of Lake Roosevelt from December, 1995 through November, 1996.

SPECIES	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	TOTAL
kokanee	0 ±0	734 ±69	0 ±0	531 ±34	0 ±0	0 ±0	0 ±0	0 ±0	0 *O	0 ±0	0 ±0	0 ±0	1,265 ±102
rainbow trout	1,473 ±175	1,433 ±134	1,142 ±551	6,549 ±415	3,237 ±255	0 ±0	2,550 ±92	43,873 ±1,306	5,410 ±56	918 ±38	3,421 ±164	434 ±28	70,440 ±3,216
walleye	0 ±0	0 ±0	0 ±0	0. ±0	0 ±0	0 ±0	103 ±4	895 ±27	0 ±0	918 ±38	0 ±0	0 ±0	1,917 ±69
smallmouth bass	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ± 0
sturgeon	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ± 0
other species*	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ± 0
Monthly Total	**1,473 ±175**	**2,167 ±202**	**1,142 ±551**	**7,080 ±449**	**3,237 ±255**	**0 ± 0**	**2,653 ±96**	**45,179 ±1,333**	**5,410 ±56**	**1,837 ±75**	**3,421 ±164**	**434 ±28**	**73,622 ±3,386**

*Includes yellow perch, largemouth bass, suckers, squawfish, black crappie, chinook, bullhead, etc...

Table D.19 Total monthly and annual catch estimates ± 95% confidence intervals from all fish observed by creel clerks on all sections of Lake Roosevelt from December, 1995 through November, 1996.

SPECIES	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	‘TOTAL
kokanee	0 ±0	734 ±69	0 ±0	531 ±34	0 [illegible]	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	1,265 ±102
rainbow trout	1,473 ±175	1,466 ±146	5,049 *856	6,614 ±422	3.237 ±255	0 ±0	2,714 ±100	45,313 ±1,372	5,446 ±60	947 ±39	4,103 ±210	552 ±42	76,914 ±3,677
walleye	146 ±32	0 ±0	0 ±0	15 ±3	170 ±27	4,745 ±428	19,151 ±1,109	116,559 *5,114	963 ±106	1,124 ±47	0 ±0	0 ±0	142,873 ±6,868
smallmouth bass	0 ±0	0. ±0	0 ±0	0 ±0	0 ±0	0 ±0	6,642 ±241	4,811 ±207	I8 ±2	0 ±0	0 ±0	0 ±0	11,471 ±480
sturgeon	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ± 0
other species*	0 ±0	0 ±0	0 ±0	15 ±3	24 ±4	132 ±12	304 ±18	144 ±7	0 ±0	0 ±0	0 ±0	0 ±0	619 ±44
Monthly Total	**1,619 ±207**	**2,200 ±214**	**5,049 ±856**	**7,176 ±463**	**3,431 ±286**	**4,877 ±440**	**28,811 ±1,468**	**166,827 ±6,700**	**6,428 ±168**	**2,071 ±86**	**4,103 ±210**	**552 ±42**	**233,144 ±11,140**

*Includes yellow perch, largemouth bass, suckers, squawfish, black crappie, chinook, bullhead, etc...

Table D.20 Monthly and annual catch estimates ± 95% confidence intervals for all fish species surveyed in Section 1 of Lake Roosevelt from December, 1995 through November, 1996.

SPECIES	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	TOTAL
kokanee	0 +/-O	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ± 0
rainbow trout	0 ±0	33 ±12	26 ±12	0 ±0	0 ±0	0 ±0	61 ±4	1,440 ±66	36 ±4	29 ±1	0 ±0	118 ±14	1,744 ±113
walleye	146 ±32	0 ±0	0 ±0	15 ±3	170 ±27	4,745 ±428	18,292 ±1,083	43,494 ±1,989	963 ±106	206 ±9	0 ±0	0 ±0	68,031 ±3,679
smallmouth bass	0 ±0	0 ±0	0 +/-0	0 ±0	0 ±0	0 ±0	61 ±4	0 ±0	18 2	0 +/-0	0 ±0	0 ±0	79 ± 6
sturgeon	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ± 0
other species*	0 ±0	0 ±0	0 ±0	15 ±3	24 ±4	132 ±12	304 ±18	144 ±7	0 ±0	0 ±0	0 ±0	0 ±0	619 ±44
Monthly Total	**146 ±32**	**33 ±12**	**26 ±12**	**31 ± 7**	**194 ±30**	**4,877 ±440**	**18,717 ±1,109**	**45,079 ±2,062**	**1,018 ±112**	**235 ±11**	**0 ± 0**	**118 ±14**	**70,474 ±3,841**

*Includes yellow perch, largemouth bass, suckers, squawfish, black ciappie, chinook, bullhead, etc...

Table D.21 Monthly and annual catch estimates ± 95% confidence intervals for all fish species surveyed in Section 2 of Lake Roosevelt from December, 1995 through November, 1996.

SPECIES	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	TOTAL
kokanee	0	0	0	0	0	0	0	0	0	0	0	0	0
	±0	±0	±0	·±0	±0	±0	±0	±0	±0	±0	±0	±0	± 0
rainbow trout	0	0	3,881	65	0	0	0	0	0	0	682	0	4,628
	±0	±0	±293	±7	±0	±0	±0	±0	±0	±0	±46	±0	+/-345
walleye	0	0	0	0	0	0	583	72,170	0	0	0	0	72,753
	±0	±0	+/-O	±0	±0	±0	±16	±3,098	±0	±0	±0	±0	±3,115
smallmouth bass	0	0	0	0	0	0	0	4,811	0	0	0	0	4,811
	±0	±0	+/-0	±0	±0	±0	±0	±207	±0	±0	±0	±0	±207
sturgeon	0	0	0	0	0	0	0	0	0	0	0	0	0
	±0	±0	±0	±0	±0	±0	±0	±0	±0	±0	±0	[illegible]	± 0
other species*	0	0	0	0	0	0	0	0	0	0	0	0	0
	±0	±0	±0	±0	±0	±0	±0	±0	±0	±0	±0	±0	± 0
Monthly Total	**0**	**0**	**3,881**	**65**	**0**	**0**	**583**	**76,981**	**0**	**0**	**682**	**0**	**82,192**
	± 0	**± 0**	**±293**	**± 7**	**± 0**	**± 0**	**±16**	**±3,305**	**± 0**	**± 0**	**±46**	**± 0**	**±3,667**

*Includes yellow perch, largemouth bass, suckers, squawfish, black crappie, chinook, bullhead, etc...

Table D.22 Monthly and annual catch estimates ± 95% confidence intervals for all fish species surveyed in Section 3 of Lake Roosevelt from December, 1995 through November, 1996.

SPECIES	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	TOTAL
kokanee	0 ±0	734 ±69	0 ±0	531 ±34	0 ItO	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	1,265 ±102
rainbow trout	1,473 ±175	1,433 ±134	1,142 ±551	6,549 ±415	3,237 +/-255	0 ±0	2,653 ±96	43,873 ±1,306	5,410 ±56	918 ±38	3,421 ±164	434 ±28	70,543 ±3,219
walleye	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	276 ±10	895 ±27	0 ±0	918 ±38	0 ±0	0 ±0	2,089 ±74
smallmouth bass	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	6,581 ±237	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	6,581 ±237
sturgeon	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0
other species*	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0
Monthly Total	**1,473 ±175**	**2,167 ±202**	**1,142 ±551**	**7,080 ±449**	**3,237 ±255**	**0 ±0**	**9,510 ±343**	**44,768 ±1,333**	**5,410 ±56**	**1,836 ±75**	**3,421 ±164**	,434 **±28**	80,478 **±3,632**

*Includes yellow perch, largemouth bass, suckers, squawfish, black crappie, chinook, bullhead, etc...

APPENDIX E

Fishery Surveys and Relative Abundance

Table E.l **Annual electrofishing results for 1996 split by month including number of fish collected (No.), relative abundance (%) and catch per unit effort (CPUE) based on time (hrs).**

	May			July			October			Total		
Effort (hrs)	9.6			9.6			7.8			27.0		
Species	**No.**	**-%**	**CPUE**	**No.**	**%**	**CPUE**	**No.**	**%**	**CPUE**	**No.**	**%**	**CPUE**
bridgelip sucker	60	7	6.24	0	0	0.00	0	0	0.00	60	2	2.22
brook trout	20	2	2.08	1	<l	0.10	5	<l	0.64	.26	1	0.96
brown trout	37	4	3.85	21	2	2.19	0	0	0.00	58	2	2.15
burbot	12	1	1.25	2	<l	0.21	82	8	10.50	96	3	3.55
carp	14	2	1.46	44	5	4.58	1	<1	0.13	59	2	2.18
Cottus spp.	0	0	0.00	25	3	2.60	3	<1	0.38	28	1	1.04
cutthroat trout	0	0	0.00	1	< l	0.10	1	<1	0.13	2	<l	0.07
kokanee salmon	1	<l	0.10	3	< l	0.31	115	12	14.72	119	4	4.40
lake whitefish	9	1	0.94	1	<l	0.10	6	0	0.77	16	< l	0.59
largescale sucker	395	45	41.10	404	43	42.08	421	43	53.91	1,220	44	45.15
longnose sucker	36	4	3.75	0	0	0.00	0	0	0.00	36	1	1.33
mountain whitefish	0	0	0.00	0	0	0.00	2	<l	0.26	2	<l	0.07
rainbow trout	72	8	7.49	55	6	5.73	60	6	7.68	187	7	6.92
smallmouth bass	65	8	6.76	110	12	11.46	4	<l	0.51	179	6	6.62
squawfish	6	<l	0.62	20	2	2.08	29	3	3.71	55	2	2.04
tenth	2	<l	0.21	1	<l	0.10	0	0	0.00	3	<1	0.11
Catostomus spp.	0	0	0.00	0	0	0.00	0	15	0.00	128	5	0.00
walleye	203	23	21.12	244	26	25.42	95	10	12.16	542	19	20.06
yellow perch	0	0	0.00	18	2	1.88	30	3	3.84	48	2	1.78
Totals	872		90.74	950		98.96	982		109.35	2,804		99.04

Table E.2 **May electrofishing results for 1996 split by location including number of fish collected (No.), relative abundance (%) and catch per unit effort (CPUE) based on time (hrs).**

	Kettle Falls			Gifford			Hunters			Porcupine Bav		
Effort (hrs)		**1.3**			**0.8**			0.7			**1.0**	
Species	**No.**	**%**	**CPUE**	**No.**	**%**	**CPUE**	**No.**	**%**	**CPUE**	**No.**	**%**	**CPUE**
bridgelip sucker	60	32	45.8	0	0	0.00	0	0	0.00	0	0	0.00
brook trout	0	*0*	*0.00*	**0**	**0**	*0.00*	**0**	**0**	*0.00*	**0**	**0**	*0.00*
brown trout	0	*0*	*0.00*	**0**	**0**	*0.00*	**0**	**0**	*0.00*	**0**	**0**	*0.00*
burbot	1	<l	0.76	4	7	5.00	6	13	9.09	**0**	**0**	*0.00*
carp	0	0	0.00	0	0	0.00	0	0	0.00	1	2	1.00
Cottus spp.	*0*	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
cutthroat trout	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
kokanee salmon	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
lake whitefish	1	<l	0.76	1	2	1.25	1	2	1.52	4	8	4.00
largescale sucker	94	50	71.76	42	75	52.50	9	20	13.64	6	12	6.00
longnose sucker	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
mountain whitefish	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
rainbow trout	0	0	0.00	2	4	2.50	8	17	12.12	13	25	13.00
smallmouth bass	1	<l	0.76	0	0	0.00	0	0	0.00	1	2	0.00.
squawfish	2	1	1.53	0	0	0.00	0	0	0.00	0	0	0.00
tench	1	<l	‘0.76	0	0	0.00	0	0	0.00	0	0	0.00
Catostomus spp.	*0*	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
walleye	28	15	21.37	7	13	8.75	22	48	33.33	27	52	27.00
yellow perch	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
TOTALS	**128**		97.71	56		70.00	46		69.70	52		52.00

Table E.2 Continued.

	Little Falls			Seven Bays			Keller Ferry			R. Sanpoil		
Effort (hrs)	**1.8**			**1.2**			0.7			0.9		
Species	**No.**	**%**	**CPUE**	**No.**	**%**	**CPUE**	**No.**	**%**	**CPUE**	**No.**	**%**	**CPUE**
bridgelip sucker	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
brook trout	20	7	11.30	0	0	0.00	0	0	0.00	0	0	0.00
brown trout	37	12	20.90	0	0	0.00	0	0	0.00	0	0	0.00
burbot	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
carp	0	0	0.00	8	11	6.50	0	0	0.00	4	7	4.55
Cottus spp.	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
cutthroat trout	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
kokanee salmon	0	0	0.00	1	1	0.81	0	0	0.00	0	0	0.00
lake whitefish	0	0	0.00	1	1	0.81	0	0	0.00	1	2	1.14
largescale sucker	173	58	97.74	22	30	17.89	5	5	7.14	5	8	5.68
longnose sucker	30	10	16.95	0	0	0.00	6	6	8.57	0	0	0.00
mountain whitefish	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
rainbow	2	<I	1.13	10	14	8.13	26	26	37.14	8	13	9.09
smallmouth bass	0	0	0.00	8	11	6.50	41	41	58.57	2	3	2.27
squawfish	1	<l	0.56	1	1	0.81	0	0	0.00	2	3	2.27
tench	0	0	0.00	0	0	0.00	1	0	1.43	0	0	0.00
Catostomus spp.	0	0	0.00	0	0	0.00	0	0	0.00	5	8	5.68
walleye	38	13	21.47	22	30	17.89	21	21	30.00	34	56	38.64
yellow perch	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
TOTALS	**301**		**170.06**	**73**		59.35	**100**		**142.86**	**61**		69.32

Table E.2 Continued.

<u>$pring Canvon</u>			
Effort (hrs)		**1.3**	
Species	**No.**	**%**	**CPUE**
bridgelip sucker	0	0	0.00
brook trout	*0*	*0*	*0.00*
brown trout	*0*	*0*	*0.00*
burbot	1	3	0.79.
carp	1	3	0.79
Cottus spp.	0	0	0.00
cutthroat trout	0	0	0.00
kokanee salmon	0	0	0.00
lake whitefish	0	0	0.00
largescale sucker	17	44	13.49
longnose sucker	0	0	0.00
mountain whitefish	0	0	0.00
rainbow trout	2	5	1.59
smallmouth bass	11	28	8.73
squawfish	0	0	0.00
tench	0	0	0.00
Catostomus spp.	0	0	0.00
walleye	7	18	5.56
yellow perch	0	0	0.00
TOTALS	30		23.81

Table E.3 **July electrofishing results'for 1996 split by location including number of fish collected (No.), relative abundance (%) and catch per unit effort (CPUE) based on time (hrs).**

	Kettle Falls			Gifford			Hunters			Porcupine Bay		
Effort (hrs)		**1.3**			**0.8**			0.7			1 . 2	
Species	**No.**	**%**	**CPUE**	**No.**	**%**	**CPUE**	**No.**	**%**	**CPUE**	**No.**	**%**	**CPUE**
bridgelip sucker	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
brook trout	0	0	0.00	1	3	1.19	**0**	**0**	*0.00*	**0**	**0**	*0.00*
brown trout	0	O	0.00	0	0	0.00	**0**	**0**	*0.00*	**0**	**0**	*0.00*
burbot	0	0	0.00	0	0	0.00	2	2	2.86	**0**	**0**	*0.00*
carp	0	0	0.00	1	3	1.19	4	4	5.71	3	4	2.56
co ttus spp.	0	0	0.00	0	0	0.00	5	5	7.14	0	0	0.00
cutthroat trout	0	0	0.00	0	0	0.00	1	1	1.43	0	0	0.00
kokanee salmon	2	2	1.57	0	0	0.00	0	0	0.00	0	0	0.00
lake whitefish	1	<l	0.79	0	0	0.00	0	0	0.00	0	0	0.00
largescale sucker	91	73	71.65	9	25	10.71	42	44	60.00	33	39	28.21
longnose sucker	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
mountain whitefish	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
rainbow trout	1	<l	0.79	3	8	3.57	8	8	11.43	0	0	0.00
smallmouth bass	6	5	4.72	2	6	2.38	0	0	0.00	21	25	17.95
squawfish	1	<1	0.79	4	11	4.76	0	0	0.00	0	0	0.00
tench	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
Catostomus spp.	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
walleye	22	18	17.32	16	44	19.05	30	32	42.86	17	20	14.53
yellow perch	1	<l	0.79	0	0	0.00	3	3	4.29	11	13	9.40
TOTALS	**125**		98.43	36		42.86	95		**135.71**	**85**		72.65

Table E.3 Continued.

	Little Falls			Seven Bavs			Keller Ferry			Sanpoil		
Effort (hrs)	**1.0**			0.9			0.8			2.0		
Species	**N .**	**%**	**CPUE**	**No.**	**%**	**CPUE**	**No.**	**%**	**CPUE**	**. No.**	**%**	**CPUE**
bridgelip sucker	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
brook trout	20	7	11.30	**0**	**0**	0.00	0	O	0.00	0	0	0.00
brown trout	37	12	20.90	1	<1	1.06	0	0	0.00	0	0	0.00
burbot	**0**	**0**	0.00	0	0	0.00	0	0	0.00	0	0	0.00
carp	**0**	**0**	0.00	24	15	25.53	6	12	7.23	3	1	1.49
Cottus spp.	**0**	**0**	0.00	20	12	21.28	0	0	0.00	0	0	0.00
cutthroat trout	**0**	**0**	0.00	**0**	**0**	0.00	0	0	0.00	0	0	0.00
kokanee salmon	**0**	**0**	0.00	**0**	**0**	0.00	0	0	0.00	1	<l	0.50
lake whitefish	**0**	**0**	0.00	**0**	**0**	0.00	0	0	0.00	0	0	0.00
largescale sucker	173	58	97.74	35	22	37.23	18	35	21.69	90	33	44.78
longnose sucker	30	10	16.95	**0**	**0**	0.00	0	0	0.00	0	0	0.00
mountain whitefish	0	0	0.00	**0**	**0**	0.00	0	0	0.00	0	0	0.00
rainbow trout	2	<1	1.13	15	9	15.96	5	10	6.02	12	4	5.97 ,
smallmouth bass	0	0	0.00	6	4	6.38	17	33	20.48	25	9	12.44
squawfish	1	<l	0.56	**0**	**0**	0.00	0	0	0.00	8	3	3.98
tench	0	0	0.00	1	<1	1.06	0	0	0.00	0	0	0.00
Catostomus spp.	0	0	0.00	0	0	0.00	0	0	0.00	89	33	44.28
walleye	38	13	21.47	61	37	64.89	5	10	6.02	39	14	19.40
yellow perch	**0**	**0**	0.00	0	0	0.00	0	0	0.00	3	1	1.49
TOTALS	301		170.06	163		173.40	51		61.45	270		134.33

Table E.3 Continued.

Spring Canvon

Effort (hrs)		0.8	
Species	**No.**	**%**	**CPUE**
bridgelip sucker	0	0	0.00
brook trout	0	0	0.00
brown trout	0	0	0.00
burbot	0	0	0.00
carp	3	5	3.57
cottus spp.	0	0	0.00
cutthroat trout	0	0	0.00
kokanee salmon	0	0	0.00
lake whitefish	0	0	0.00
largescale sucker	18	29	21.43
longnose sucker	0	0	0.00
mountain whitefish	0	0	0.00
rainbow trout	7	11	8.33
smallmouth bass	31	50	36.90
squawfish	0	0	0.00
tench	0	0	0.00
Catostomus spp.	0	0	0.00
walleye	3	5	3.57
yellow perch	0	0	0.00
TOTALS	62		73.81

Table E.4 **October electrofishing results for 1996 split by location including number of fish collected (No.), relative abundance (%) and catch per unit effort (CPUE) based on time (hrs).**

	Kettle Falls			Gifford			Hunters			Porcupine Bav		
Effort (hrs)		1.1			1.0			0.9			1.0	
Species	**No..**	**%**	**CPUE**	**No.**	**%**	**CPUE**	**No.**	**%**	**CPUE**	**No.**	**%**	**CPUE**
bridgelip sucker	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
brook trout	**0**	**0**	*0.00*	4	11	3.88	*0*	*0*	*0.00*	*0*	*0*	*0.00*
brown trout	**0**	**0**	*0.00*	0	0	0.00	*0*	*0*	*0.00*	*0*	*0*	*0.00*
burbot	16	7	14.55	5	14	4.85	49	28	55.68	**6**	10	**6.06**
carp	0	0	0.00	0	0	0.00	0	0	0.00	**0**	**0**	**0.00**
Cottus spp.	0	0	0.00	0	0	0.00	0	0	0.00	**0**	**0**	**0.00**
cutthroat trout	0	0	0.00	0	0	0.00	0	0	0.00	**0**	**0**	**0.00**
kokanee salmon	3	1	2.73	3	9	2.91	12	7	13.64	**26**	**41**	**26.26**
lake whitefish	2	<l	1.82	0	0	0.00	0	0	0.00	**0**	**0**	**0.00**
largescale sucker	156	68	141.82	14	40	13.59	102	58	115.91	**7**	11	7.07
longnose sucker	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
mountain whitefish	2	<l	1.82	0	0	0.00	0	0	0.00	0	0	0.00
rainbow	10	4	9.09	2	6	1.94	0	0	0.00	1	2	1.01
smallmouth bass	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
squawfish	10	4	9.09	0	0	0.00	1	<l	1.14	0	0	0.00
tench	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
Ca tostomus spp.	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
walleye	30	13	27.27	7	20	6.80	12	7	13.64	23	37	23.23
yellow perch	0	0	0.00	0	0	0.00	1	<l	1.14	0	0	0.00
TOTALS	**229**		**208.18**	**35**		**33.98**	**177**		**201.14**	**63**		**63.29**

Table E.4 Continued.

	Little Falls			Seven Bays			Keller Ferry			Sanpoil R.		
Effort (hrs)	**0.0**			0.9			0.9			**1.1**		
Species	**No.**	**%**	**CPUE**	**No.**	**%**	**CPUE**	**No.**	**%**	**CPUE**	**No.**	**%**	**CPUE**
bridgelip sucker	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
brook trout	0	0	0.00	1	<1	1.16	0	0	0.00	0	0	0.00
brown trout	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
burbot	0	0	0.00	2	2	2.33	3	7	3.19	1	<1	0.95
carp	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
Cottus spp.	0	0	0.00	3	2	3.49	0	0	0.00	0	0	0.00
cutthroat trout	0	0	0.00	1	<1	1.16	0	0	0.00	0	0	0.00
kokanee salmon	0	0	0.00	67	53	77.91	0	0	0.00	4	3	3.81
lake whitefish	0	0	0.00	0	0	0.00	0	0	0.00	4	3	3.81
largescale sucker	0	0	0.00	24	19	27.91	28	64	29.79	35	26	33.33
longnose sucker	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
mountain whitefish	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
rainbow	0	0	0.00	6	5	6.98	6	14	6.38	23	17	21.90
smallmouth bass	0	0	0.00	1	<1	1.16	0	0	0.00	1	<1	0.95
squawfish	0	0	0.00	0	0	0.00	0	0	0.00	18	13	17.14
tench	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
Catostomus spp.	0	0	0.00	0	0	0.00	0	0	0.00	34	25	32.38
walleye	0	0	0.00	6	5	6.98	7	16	7.45	3	2	2.86
yellow perch	0	0	0.00	15	12	17.44	0	0	0.00	14	10	13.33
TOTALS	**0**		**0.00**	**126**		**146.51**	**44**		**46.81**	**137**		**130.48**

Table E.4 'Continued.

Spring Canyon			
Effort (hrs)		**1.0**	
Species	**No.**	**%**	**CPUE**
bridgelip sucker	0	0	0.00
brook trout	0	0	0.00
brown trout	0	0	0.00
bull trout	0	0	0.00
burbot	0	0	0.00
carp	1	2	1.04
cottus spp.	0	0	0.00
cutthroat trout	0	0	0.00
kokanee salmon	0	0	0.00
lake whitefish	0	0	0.00
largescale sucker	21	49	21.88
longnose sucker	0	0	0.00
mountain whitefish	0	0	0.00
rainbow trout	12	28	12.50
smallmouth bass	2	5	2.08
squawfish	0	0	0.00
tench	0	0	0.00
Catostomus spp.	0	0	0.00
walleye	7	16	7.29
yellow perch	0	0	0.00
TOTALS	43		44.79

Table E.5. Annual gillnet set results for 1996 split by sampling period including number of fish collected (No.), relative abundance (%) and catch per unit effort (CPUE) based on time (hrs).

	May			**July**			**October**			**Total**		
Effort (min)	55.8			53.4			92.0			201.2		
Species	**No.**	**%**	**CPUE**	**No.**	**%**	**CPUE**	**No.**	**%**	**CPUE**	**No.**	**%**	**CPUE**
bridgelip sucker	0	0	0.00	0	0	0.00	1	<1	0.01	1	<1	0.00
brown bullhead	0	0	0.00	1	<1	0.02	0	0	0.00	1	<1	0.00
burbot	19	19	0.34	3	2	0.06	14	12	0.15	36	10	0.18
carp	1	1	0.02	0	0	0.00	3	3	0.03	4	1	0.02
kokanee salmon	0	0	0.00	5	4	0.09	11	9	0.12	16	5	0.08
lake whitefish	57	57	1.02	83	60	1.55	44	37	0.48	184	51	0.91
largescale sucker	7	7	0.13	5	4	0.09	11	9	0.12	23	6	0.11
longnose sucker	4	4	0.07	1	<1	0.02	0	0	0.00	5	1	0.02
rainbow trout	4	4	0.07	12	9	0.22	6	5	0.07	22	6	0.11
squawfish	3	3	0.05	0	0	0.00	0		0.00	3	<1	0.01
walleye	5	5	0.09	21	15	0.39	26	22	0.28	52	15	0.26
yellow perch	1	1	0.02	7	5	0.13	3	3	0.03	11	3	0.05
TOTALS	**101**		**1.81**	**138**		**2.58**	**119**		**1.29**	**358**		**1.78**

Table E.6 **May gillnet results for 1996 split by location including number of fish collected (No.), relative abundance (%) and catch per unit effort (CPUE) based on time (hrs).**

	Kettle Falls			Gifford			Hunters			Porcupine Bay		
Effort (hrs)	2.9			11.3			5.4			2.8		
Species	**No.**	**%**	**CPUE**	**No.**	**%**	**CPUE**	**No.**	**%**	**CPUE**	**No.**	**%**	**CPUE**
bridgelip sucker	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
brown bullhead	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
burbot	5	25	1.72	4	100	0.35	1	5	0.19	4	17	1.43
carp	0	0	0.00	0	0	0.00	0	0	0.00	1	4	0.36
kokanee salmon	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
lake whitefish	10	50	3.45	0	0	0.00	13	68	2.41	19	79	6.79
largescale sucker	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
longnose sucker	0	0	0.00	0	0	0.00	2	11	0.37	0	0	0.00
rainbow trout	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
squawfish	2	10	0.69	0	0	0.00	1	5	0.19	0	0	0.00
walleye	2	10	0.69	0	0	0.00	2	11	0.37	0	0	0.00
yellow perch	1	5	0.34	0	0	0.00	0	0	0.00	0	0	0.00
TOTALS	20		6.90	4		0.35	19		3.52	24		8.57

Table E.6 Continued.

	Seven Bays			Keller Ferry			Sanpoil R.			Spring Canyon		
Effort (hrs)	**4.3**			**4.5**			**11.2**			**13.4**		
Species	**No.**	**%**	**CPUE**	**No.**	**%**	**CPUE**	**No.**	**%**	**CPUE**	**No.**	**%**	**CPUE**
bridgelip sucker	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
brown bullhead	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
burbot	1	5	0.23	2	25	0.44	2	29	0.18	0	0	0.00
carp	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
kokanee salmon	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
lake whitefish	12	63	2.79	0	0	0.00	3	43	0.27	0	0	0.00
largescale sucker	3	16	0.70	3	38	0.67	1	14	0.09	0	0	0.00
longnose sucker	2	11	0.47	0	0	0.00	0	0	0.00	0	0	0.00
rainbow trout	0	0	0.00	3	38	0.67	1	14	0.09	0	0	0.00
squawfish	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
walleye	1	5	0.23	0	0	0.00	0	0	0.00	0	0	0.00
yellow perch	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
TOTALS	**19**		**4.42**	**8**		**1.78**	**7**		**0.63**	**0**		**0.00**

Table E.7 July gillnet results for 1996 split by location including nuniber of fish collected (No.), relative abundance (%) and catch per unit effort (CPUE) based on time (hrs).

	Kettle Falls			Gifford			Hunters			Porcupine Bay		
Effort (hrs)	14.3			12.5			5.5			14.6		
Species	**No.**	**%**	**CPUE**	**No.**	**%**	**CPUE**	**No.**	**%**	**CPUE**	**No.**	**%**	**CPUE**
bridgelip sucker	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
brown bullhead	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
burbot	1	4	0.07	1	14	0.08	1	7	0.18	0	0	0.00
carp	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
kokanee salmon	0	0	0.00	0	0	0.00	0	0	0.00	3	13	0.21
lake whitefish	9	35	0.63	4	57	0.32	10	71	1.82	16	70	1.10
largescale sucker	0	0	0.00	0	0	0.00	3	21	0.55	0	0	0.00
longnose sucker	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
rainbow trout	0	0	0.00	0	0	0.00	0	0	0.00	1	4	0.07
squawfish	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
walleye	12	46	0.84	0	0	0.00	0	0	0.00	3	13	0.21
yellow perch	4	15	0.28	2	29	0.16	0	0	0.00	0	0	0.00
TOTALS	26		1.82	7		0.56	14		2.55	23		1.58

Table E.7 Continued.

	Seven Bays			Keller Ferry			Sanpoil R.			Spring Canyon		
Effort (hrs)	10.1			7.9			3.3			12.3		
Species	**No.**	**%**	**CPUE**	**No.**	**%**	**CPUE**	**No.**	**%**	**CPUE**	**No.**	**%**	**CPUE**
bridgelip sucker	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
brown bullhead	0	0	0.00	1	100	0.13	0	0	0.00	0	0	0.00
burbot	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
carp	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
kokanee salmon	0	0	0.00	0	0	0.00	2	6	0.61	0	0	0.00
lake whitefish	15	58	1.49	0	0	0.00	27	75	8.18	0	0	0.00
largescale sucker	0	0	0.00	0	0	0.00	2	6	0.61	0	0	0.00
longnose sucker	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
rainbow trout	7	27	0.69	0	0	0.00	3	8	0.91	0	0	0.00
squawfish	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
walleye	3	12	0.30	0	0	0.00	2	6	0.61	0	0	0.00
yellow perch	1	4	0.10	0	0	0.00	0	0	0.00	0	0	0.00
TOTALS	**26**		**2.57**	**1**		**0.13**	**36**		**10.91**	**0**	**0**	**0.00**

Table E.8 **October gillnet results for 1996 split by location including number of fish collected (No.), relative abundance (%) and catch per unit effort (CPUE) based on time (hrs),**

	Kettle Falls			**Gifford**			**Hunters**			**Porcupine Bav**		
Effort (hrs)	**18.2**			**13.8**			**8.3**			**26.4**		
Species	**No:**	**%**	**CPUE**	**No.**	**%**	**CPUE**	**No.**	**%**	**CPUE**	**No.**	**%**	**CPUE**
bridgelip sucker	1	5	0.05	0	0	0.00	0	0	0.00	0	0	0.00
brown bullhead	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
burbot	2	11	0.11	4	18	0.29	2	10	0.24	0	0	0.00
carp	0	0	0.00	2	9	0.14	0	0	0.00	0	0	0.00
kokanee salmon	3	16	0.16	3	14	0.22	1	5	0.12	0	0	0.00
lake whitefish	3	16	0.16	2	9	0.14	16	76	1.93	0	0	0.00
largescale sucker	0	0	0.00	2	9	0.14	1	5	0.12	2	100	0.08
longnose sucker	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
rainbow trout	0	0	0.00	1	5	0.07	0	0	0.00	0	0	0.00
squawfish	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
walleye	10	53	0.55	8	36	0.58	0	0	0.00	0	0	0.00
yellow perch	0	0	0.00	0	0	0.00	1	5	0.12	0	0	0.00
TOTALS	**19**		**1.04**	**22**		**1.59**	**0**		2.53	2		0.08

Table E.8 Continued.

	Seven Bays			Keller Ferry			Sanpoil R.			Spring Canyon		
Effort (hrs)	11.4			4.1			7.6			2.4		
Species	**No.**	**%**	**CPUE**	**No.**	**%**	**CPUE**	**No,**	**%**	**CPUE**	**No.**	**%**	**CPUE**
bridgelip sucker	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
brown bullhead	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
burbot	1	4	0.09	0	0	0.00	5	23	0.66	0	0	0.00
carp	0	0	0.00	0	0	0.00	1	5	0.13	0	0	0.00
kokanee salmon	4	16	0.35	0	0	0.00	0	0	0.00	0	0	0.00
lake whitefish	17	68	1.49	0	0	0.00	6	27	0.79	0	0	0.00
largescale sucker	0	0	0.00	0	0	0.00	0	0	0.00	6	86	2.50
longnose sucker	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
rainbow trout	0	0	0.00	0	0	0.00	5	23	0.66	0	0	0.00
squawfish	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
walleye	2	8	0.18	1	100	0.24	4	18	0.53	1	14	0.42
yellow perch	1	4	0.09	0	0	0.00	1	5	0.13	0	0	0.00
TOTALS	25		2.19	1		0.24	22		2.89	7		2.92

APPENDIX F

Feeding Habits

Table F.l **Percentage by number, percentage by weight, frequency of occurrence and index of relative importance (IRI) of food items for all kokanee (n = 15) sampled in 1996.**

PREY ITEM	% by Number	% by Weight	Frequency of Occurrence	IRI
Cladocera				
D.pulex	*39.38*	34.35	33.33	30.88
L. kindtii	13.66	18.58	33.33	18.92
Daphnia spp.	26.76	28.63	40.00	27.52
B. longirostris	18.59	11.18	6.67	10.51
Eucopepoda				
Copepoda spp.	0.01	0.03	6.67	1.93
Diptera				
Chironomidae pupa	i.59	7.18	20.00	8.30
Terrestrial				
Insects	0.02	0.04	6.67	1.94

Table F.2 **Percentage by number, percentage by weight, frequency of occurrence and index of relative importance (IRI) of food items for 0+ year old kokanee (n = 1) sampled in 1996.**

PREY ITEM	% by Number	% by Weight	Frequency of Occurrence	IRI
Diptera				
Chironomidae pupa	100.00	100.00	100.00	100.00

Table F.3 **Percentage by number, percentage by weight, frequency of occurrence and index of relative importance (IRI) of food items for l+ year old kokanee (n = 1) sampled in 1996.**

PREY ITEM	% by Number	% by Weight	Frequency of Occurrence	IRI
Cladocera				
Daphnia spp.	100.00	100.00	100.00	100.00

Table F.4 **Percentage by number, percentage by weight, frequency of occurrence and index of relative importance (IRI) of food items for 2+ year old kokanee (n = 12) sampled in 1996.**

PREY ITEM	% by Number	% by Weight	Frequency of Occurrence	IRI
Cladocera				
D. pulex	46.66	41.64	41.67	38.04
L. kindtii	16.09	22.21	33.33	20.97
Daphnia spp.	14.29	20.94	33.33	20.07
B. longirostris	22.03	13.55	8.33	12.85
Eucopepoda				
Copepoda spp.	0.01	0.04	8.33	2.45
Diptera				
Chironomidae pupa	0.90	1.57	8.33	3.16
Terrestrial				
Insects	0.02	0.05	8.33	2.46

Table F.5 **Percentage by number, percentage by weight, frequency of occurrence and index of relative importance (IRI) of food items for 3+ year old kokanee (n = 1) sampled in 1996.**

PREY ITEM	% by Number	% by Weight	Frequency of Occurrence	IRI
Cladocera				
L. kindtii	0.63	2.86	100.00	20.70
Daphnia spp.	99.18	96.03	100.00	59.04
Diptera				
Chironomidae pupa	0.19	1.11	100.00	20.26

Table F.6 Percentage by number, percentage by weight, frequency of occurrence and index of relative importance (IRI) of food items for all rainbow trout (n = 56) sampled in 1996.

PREY ITEM	% by Number	% by Weight	Frequency of Occurrence	IRI
Osteichthyes				
Percidae	**0.00**	0.21	1.79	0.44
Unidentified fish	**0.00**	2.48	3.57	1.33
Fish eggs	0.44	7.65	8.93	3.74
Amphipoda				
Gammarus spp.	**0.00**	0.01	3.57	**0.79**
Cladocera				
D. pulex	**74.09**	20.73	25.00	26.3 1
L. kindtii	17.16	6.27	23.21	10.24
Daphnia spp.	4.56	2.13	14.29	4.61
Eucopepoda				
Copepoda spp.	0.01	0.01	3.57	**0.79**
Basommatophora				
Physidae	0.00	**0.00**	1.79	**0.39**
Diptera				
Chironomidae pupa	0.34	2.03	**39.29**	9.15
Chironomidae larvae	0.43	3.63	14.29	4.03
Chironomidae adult	0.25	0.85	10.71	2.59
Simuliidae pupa	0.09	0.22	1.79	0.46
Simuliidae larvae	2.05	7.75	10.71	4.51
Trichoptera				
Limnephilidae	0.02	0.27	5.36	1.24
Hydropsychidae	0.00	0.01	3.57	0.79
Hemiptera				
Corixidae	0.18	0.63	17.86	4.10
Plecoptera				
Capniidae	**0.00**	*0.00*	1.79	**0.39**
Ephemeroptera				
Baetidae	0.03	0.14	**8.93**	2.00
Ephemerellidae	0.02	0.08	3.57	0.80
Heptageniidae	0.01	0.13	7.14	1.60
Leptophlebiidae	0.00	0.01	3.57	0.79
Oligochaeta				
Lumbriculidae	0.01	1.80	7.14	1.97
Hydrachnellae				
Hydracarina	**0.00**	0.08	1.79	0.41
Terrestrial				
Insects	0.27	5.81	**26.79**	7.22
Net Pen Food	0.01	37.06	5.36	9.32

Table F.7 Percentage by number, percentage by weight, frequency of occurrence and index of relative importance (IRI) of food items for 0+ year old rainbow trout (n = 1) sampled in 1996.

PREY ITEM	% by Number	% by Weight	Frequency of Occurrence	IRI
Diptera				
Chironomidae pupa	86.05	51.05	100.00	59.27
Ephemeroptera				
Ephemerellidae	13.95	48.95	100.00	40.73

Table F.8 Percentage by number, percentage by weight, frequency of occurrence and index of relative importance (IRI) of food items for l+ year old rainbow trout (n = 14) sampled in 1996.

PREY ITEM	% by Number	% by Weight	Frequency of Occurrence	IRI
Osteichthyes				
Unidentified fish	0.11	1.92	7.14	2.07
Cladocera				
L. kindtii	*4.97*	0.84	7.14	**2.93**
Daphnia spp.	63.62	7.96	14.29	19.39
Diptera				
Chironomidae pupa	5.42	31.15	**64.29**	22.77
Chironomidae larvae	6.67	14.48	28.57	11.23
Chironomidae adult	0.11	0.03	7.14	1.65
Simuliidae pupa	5.42	5.00	7.14	3.97
Trichoptera .				
Limnephilidae	0.68	0.51	7.14	1.88
Hemip tera				
Corixidae	5.31	6.51	28.57	9.12
Ephemeroptera				
Baetidae	0.11	0.23	7.14	1.69
Heptageniidae	0.11	1.24	7.14	1.92
Leptophlebiidae	0.11	0.05	7.14	1.65
Oligochaeta				
Lumbriculidae	0.11	0.05	7.14	1.65
Terrestrial				
Insects	7.23	30.03	42.86	18.09

Table F.9 Percentage by number, percentage by weight, frequency of occurrence and index of relative importance (IRI) of food items for 2+ year old rainbow trout (n = 3) sampled in 1996.

PREY ITEM	% by Number	% by Weight	Frequency of Occurrence	IRI
Cladocera				
Daphnia spp.	73.08	3.87	33.33	30.08
Diptera				
Chironomidae pupa	6.41	1.09	66.67	20.23
Terrestrial				
Insects	20.5 1	95.04	66.67	49.70

Table F.10 Percentage by number, percentage by weight, frequency of occurrence and index of relative importance (IRI) of food items for 3+ year old rainbow trout (n = 29) sampled in 1996.

PREY ITEM	% by Number	% by Weight	Frequency of Occurrence	IRI
Osteichthyes				
Percidae	*0.00*	0.43	3.45	**0.79**
Unidentified fish	*0.00*	4.85	3.45	1.68
Fish eggs	0.06	12.83	10.34	4.71
Amphipoda				
Gammarus spp.	**0.00**	0.03	**6.90**	1.41
Cladocera				
D. pulex	74.76	**39.75**	44.83	32.3 1
L. kindtii	18.72	12.20	**37.93**	13.96
Daphnia spp.	3.71	3.51	17.24	4.96
Eucopepoda				
Copepoda spp.	**0.00**	**0.00**	**6.90**	1.40
Basommatophora				
Physidae	**0.00**	0.01	3.45	0.70
Diptera				
Chironomidae pupa	0.12	1.19	31.03	6.56
Chironomidae larvae	0.05	0.25	10.34	2.16
Chironomidae adult	0.27	1.71	17.24	**3.90**
Simuliidae larvae	2.05	14.37	17.24	6.83
Trichoptera				
Limnephilidae	0.01	0.51	**6.90**	1.50
Hydropsychidae	0.00	0.02	**6.90**	1.40
Hemiptera				
Corixidae	0.10	0.56	17.24	3.63
Plecoptera				
Capniidae	**0.00**	0.01	3.45	0.70
Ephemeroptera				
Baetidae	0.03	0.23	10.34	2.15
Ephemerellidae	**0.00**	0.05	3.45	0.71
Heptageniidae	0.01	0.12	**6.90**	1.42
Leptophlebiidae	0.00	0.01	3.45	0.70
Oligochaeta				
Lumbriculidae	**0.00**	**2.59**	**6.90**	1.92
Hydrachnellae				
Hydracarina	**0.00**	0.16	3.45	0.73
Terrestrial				
Insects	0.08	4.62	13.79	3.75

Table F.ll Percentage by number, percentage by weight, frequency of occurrence and index of relative importance (IRI) of food items for 4+ year old rainbow trout (n = 9) sampled in 1996.

PREY ITEM	% by Number	% by Weight	Frequency of Occurrence	IRI
Osteichthyes				
Fish eggs	5.46	2.91	22.22	7.65
Cladocera				
D. pulex	85.64	2.43	11.11	24.80
L. kindtii	*0.49*	0.47	11.11	3.02
Eucopepoda				
Copepoda spp.	0.14	0.03	11.11	2.82
Diptera				
Chironomidae pupa	0.81	0.02	11.11	2.99
Chironomidae larvae	3.87	6.40	11.11	5.35
Simuliidae larvae	2.62	1.46	11.11	3.80
Hemiptera				
Corixidae	0.03	0.16	11.11	2.82
Ephemeroptera				
Baetidae	0.11	0.05	11.11	2.82
Heptageniidae	0.03	0.04	11.11	2.79
Oligochaeta				
Lumbriculidae	0.05	1.15	11.11	3.08
Terrestrial				
Insects	0.68	2.26	33.33	9.07
Net Pen Food	0.08	82.63	33.33	29.01

Table F.12 Percentage by number, percentage by weight, frequency of occurrence and index of relative importance (IRI) of food items for all walleye (n = 126) sampled in 1996.

PREY ITEM	% by Number	% by Weight	Frequency of Occurrence	IRI
Osteichthves				
Catostdmidae	4.69	2.55	3.17	3.25
Cottidae	14.26	4.15	19.05	11.68
Cyprinidae	5.25	0.19	0.79	1.94
Percidae	3.56	7.23	6.35	5.35
Salmonidea	10.32	67.76	12.70	28.31
Unidentified fish	23.08	16.26	46.03	26.63
Amphipoda				
Gammeras spp.	0.38	*0.00*	1.59	0.61
Cladocera				
L. kindtii	14.82	0.23	3.17	5.69
B. longirostris	0.19	0.00	0.79	0.31
Diptera				
Chironomidae pupa	3.94	0.01	7.94	3.71
Chironomidae larvae	15.95	0.14	4.76	6.50
Simuliidae larvae	0.19	0.00	0.79	0.3 1
Trichoptera				
Limnephilidae	0.38	0.00	1.59	0.61
Hydropsychidae	0.38	0.00	0.79	0.36
Brachycentridae	0.19	0.01	0.79	0.31
Hemiptera				
corixidae	0.19	0.00	0.79	0.3 1
Plecop tera				
Nemouridae	0.19	0.00	0.79	0.3 1
Pteronarcydae	0.19	0.00	0.79	0.3 1
Ephemeroptera				
Ephemerellidae	0.19	0.00	0.79	0.3 1
Odonata				
Zygoptera	0.94	1.00	3.97	1.84
Oligochaeta				
Lumbriculidae	0.19	0.00	0.79	0.3 1
Terrestrial				
Insects	0.56	0.46	2.38	1.06

Table F.13 Percentage by number, percentage by weight, frequency of occurrence and index of relative importance (IRI) of food items for l+ year old walleye (n = 19) sampled in 1996.

PREY ITEM	% by Number	% by Weight	Frequency of Occurrence	IRI
Osteichthyes				
Catostomidae	16.79	8.37	10.53	10.76
cottidae	32.85	82.99	47.37	49.22
Unidentified fish	10.95	6.94	26.32	13.33
Amphipoda				
Gammeras spp.	0.73	0.12	5.26	1.84
Cladocera				
L. kindtii	33.58	0.87	10.53	13.56
Diptera				
Chironomidae pupa	3.65	0.39	21.05	7.57
Trichoptera				
Limnephilidae	0.73	0.01	5.26	1.81
Odonata				
Zygoptera	0.73	0.3 1	5.26	1.90

Table F.14 Percentage by number, percentage by weight, frequency of occurrence and index of relative importance (IRI) of food items for 2+ year old walleye (n = 34) sampled in 1996.

PREY ITEM	% by Number	% by Weight	Frequency of Occurrence	IRI
Osteichthyes				
Catostomidae	1.36	44.32	5.88	15.79
cottidae	5.44	25.55	23.53	16.70
Cyprinidae	19.05	3.35	2.94	7.76
Percidae	2.72	1.12	2.94	2.08
Salmonidae	2.72	6.49	5.88	4.62
Unidentified fish	33.33	14.91	44.12	28.29
Amphipoda				
Gammeras spp.	0.68	0.01	2.94	1.11
Cladocera				
L. kindtii	22.45	4.01	5.88	9.91
Diptera				
Chironomidae pupa	4.76	0.08	5.88	3.28
Chironomidae larvae	3.40	0.09	8.82	3.77
Trichoptera				
Hydropsychidae	1.36	0.02	5.88	2.22
Plecoptera				
Nemouridae	0.68	0.01	2.94	1.11
Pteronarcy dae	0.68	0.04	2.94	1.12
Ephemeroptera				
Ephemerellidae	0.68	0.01	2.94	1.11
Odonata				
Zygoptera	0.68	0.02	2.94	1.11

Table F.15 Percentage by number, percentage by weight, frequency of occurrence and index of relative importance (IRI) of food items for 3+ year old walleye (n = 27) sampled in 1996.

PREY ITEM	% by Number	% by Weight	Frequency of Occurrence	IRI
Osteichthves				
Cottidae	14.29	17.09	14.81	14.17
Cyprinidae	0.00	0.00	0.00	0.00
Percicdae	1.50	2.25	7.41	3.43
Salmonidae	0.75	26.40	3.70	9.47
Unidentified fish	16.54	41.04	48.15	32.44
Cladocera				
B. longirostris	0.75	0.01	3.70	1.37
Diptera				
Chironomidae pupa	6.77	0.06	14.81	6.64
Chironomidae larvae	54.14	1.47	3.70	18.20
Simuliidae larvae	0.75	0.00	3.70	1.37
Trichoptera				
Limnephilidae	0.75	0.00	3.70	1.37
Brachycentridae	0.75	0.08	3.70	1.39
Hemiptera				
corixidae	0.75	0.01	3.70	1.37
Odonata				
Zygoptera	1.50	11.48	7.41	6.26
Terrestrial				
Insects	0.75	0.11	7.41	2.54

Table F.16 Percentage by number, percentage by weight, frequency of occurrence and index of relative importance (IRI) of food items for 4+ year old walleye (n = 30) sampled in 1996.

PREY ITEM	% by Number	% by Weight	Frequency of Occurrence	IRI
Osteichthyes				
cottidae	**4.94**	0.54	10.00	4.89
Percidae	16.05	11.65	16.67	14.01
Salmonidae	35.80	78.11	26.67	44.39
Unidentified fish	32.10	9.69	53.33	30.04
Diptera				
Chironomidae larvae	9.88	0.01	6.67	5.23
Oligochaeta				
Lumbriculidae	1.23	0.00	3.33	1.44

Table F.17 Percentage by number, percentage by weight, frequency of occurrence and index of relative importance (IRI) of food items for 5+ year old walleye (n = 10) sampled in 1996.

PREY ITEM	% by Number	% by Weight	Frequency of Occurrence	IRI
Osteichthyes				
Salmonidae	64.52	57.97	50.00	52.27
Unidentified fish	32.26	40.28	70.00	43.19
Terrestrial				
Insects	3.23	1.76	10.00	4.54

Table F.18 Percentage by number, percentage by weight, frequency of occurrence and index of relative importance (IRI) of food items for 6+ year old walleye (n = 5) sampled in 1996.

PREY ITEM	% by Number	% by Weight	Frequency of Occurrence	IRI
Osteichthyes				
cottidae	12.50	0.30	20.00	10.25
Salmonidae	25.00	94.69	20.00	43.65
Unidentified fish	37.50	4.75	40.00	25.70
Odonata				
Zygoptera	12.50	0.16	20.00	10.21
Terrestrial				
Insects	12.50	0.09	20.00	10.19

Table F.19 Percentage by number, percentage by weight, frequency of occurrence and index of relative importance (IRI) of food items for 7+ year old walleye (n = 1) sampled in 1996.

PREY ITEM	% by Number	% by Weight	Frequency of Occurrence	IRI
Osteichthyes				
Unidentified fish	100.00	100.00	100.00	100.00

SECTION 2

ARTIFICIAL IMPRINTING OF JUVENILE KOKANEE SALMON *(Oncorhynchus nerka)*: IMPLICATIONS FOR OPERATING LAKE ROOSEVELT KOKANEE SALMON HATCHERIES

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ABSTRACT

The purpose of the Imprinting Program, which began as a sub-contract to the Lake Roosevelt Monitoring Program in 199 1, was to determine the critical period for thyroxine-induced olfactory imprinting in kokanee salmon. The objectives of the present investigation were to: (1) repeat investigations which would determine the critical period(s) for olfactory imprinting and (2) assess the best times and locations to release kokanee in order to prevent entrainment, and improve returns to creel and egg collection sites. From 1992 to 1996, coded wire tagged (CWT) fish were released as residualized smolts into Lake Roosevelt. These fish were imprinted at different life stages and were given an adipose clip and a distinctive coded wire tag. Returning adults would enable us to determine (1) the number entrained from Lake Roosevelt (2) the number harvested by anglers; (2) the number homing to egg collection sites, and (4) the number straying to other locations. Results continued to show that kokanee can be successfully imprinted to artificial odors - morpholine and phenethyl alcohol - as juveniles from hatch through swimup and again as smolts. Fish double exposed to synthetic chemicals at alevin/swimup and smolt stages had the highest rate of homing to egg collection sites (74% of the morpholine exposed fish recovered were captured at morpholine scented streams and 67% of the phenethyl alcohol exposed fish recovered were captured at phenethyl alcohol scented streams). Additionally, fish exposed to synthetic chemicals were recovered in greater numbers and displayed higher homing ability to egg collection sites than fish that were not exposed to synthetic chemicals. Fish exposed to synthetic chemicals and released at Sherman Creek had the most precise homing, with 74% of the total recovered fish captured at Sherman Creek.

Based on the results of this investigation, we recommend the following measures for the management of the Lake Roosevelt kokanee salmon fishery:

1) Release more yearling kokanee salmon into the reservoir.
2) Monitor kokanee salmon entrainment.
3) Study feasibility of collecting additional spawning kokanee at Sherman Creek.
4) Continue the egg collection site at Hawk Creek.
5) Determine if chemically imprinted and non-imprinted fish reared and released at Sherman Creek home back in equal numbers (percentages).
6) Locate alternative stocks of kokanee salmon with better genetic adaptations than Lake Whatcom fish for the Lake Roosevelt Program.
7) Assess impacts of walleye predation on kokanee salmon.

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1.0 INTRODUCTION

In 1987, the Northwest Power Planning Council (NPPC) directed Bonneville Power Administration (BPA) to construct two kokanee salmon hatcheries on Lake Roosevelt (NPPC 1987) (Figure 1). Kokanee salmon and rainbow trout planted in Lake Roosevelt would enhance the resident fishery in the reservoir as partial replacement for the loss of anadromous salmon and steelhead trout from that region caused by the construction of Grand Coulee Dam. The Lake Roosevelt Monitoring Program was designed in 1988 to evaluate the effectiveness of Lake Roosevelt kokanee salmon hatcheries. In 1996, one of the objectives of this program was to identify temporal and spatial release sites for hatchery reared kokanee salmon which would minimize entrainment from Lake Roosevelt, maximize angler harvest, and maximize homing. The specific objectives were to:

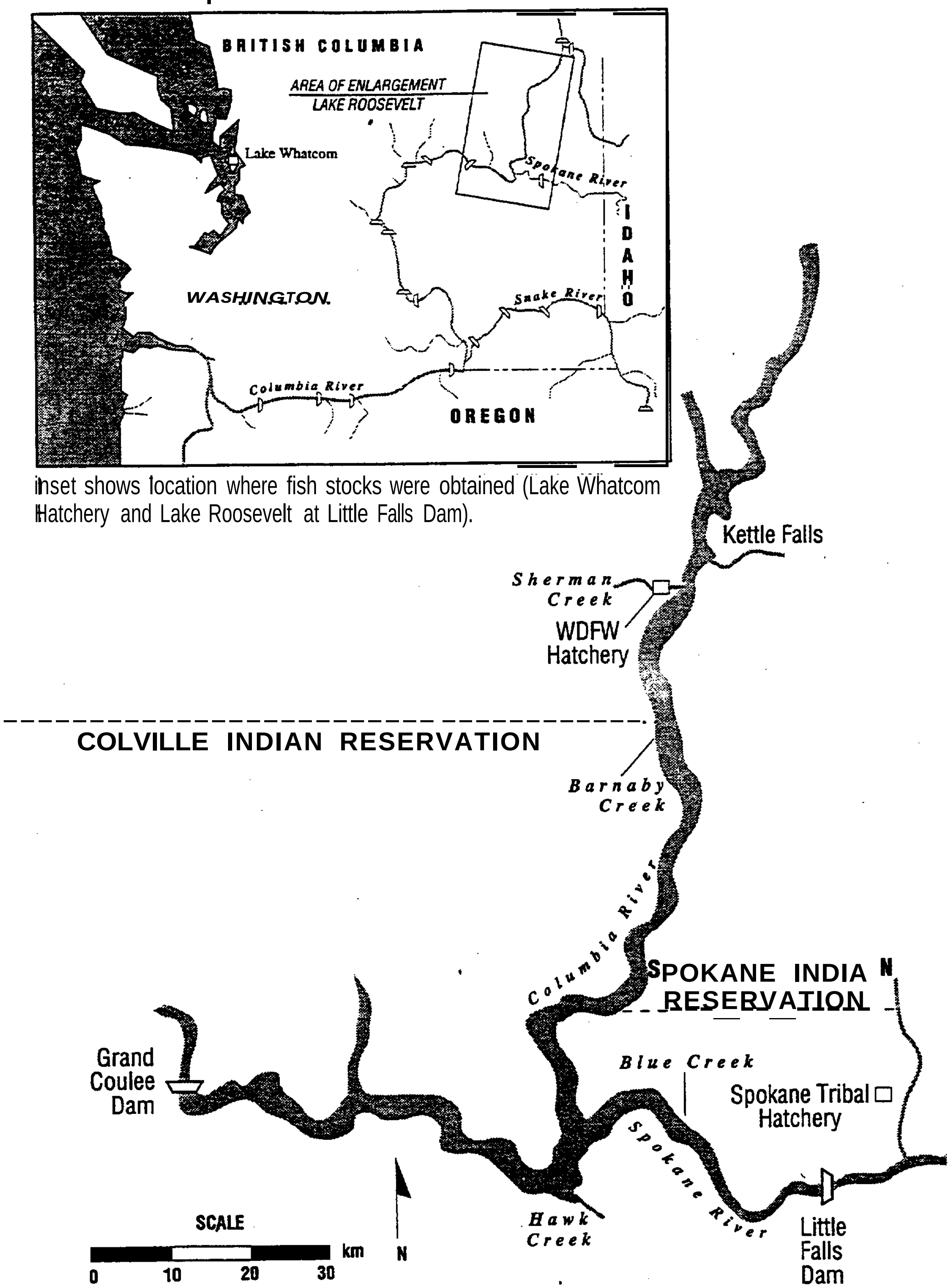
(1) Repeat coded wire tagging investigations in Lake Roosevelt to determine that the critical period(s) for olfactory imprinting in kokanee salmon are from hatch through swimup and at the smolt stage.

(2) Assess the best times and locations to release kokanee salmon in terms of preventing entrainment below Grand Coulee Dam, and improving returns to creel and egg collection sites.

Both of these objectives were addressed through experiments carried out from 1992 through 1996 (Scholz et *al.* 1992, 1993; Tilson et al. 1994, 1995, 1996). Fish were released from 1992 to 1996 and monitored from 1993 to 1996. Fish released as fry from 1992-1995 could be recovered from 1993-1998 and fish released as smolts from 1992-1996 could be recaptured from 1993-1998 (Table 1, Appendix B, C).

Previous imprinting experiments with kokanee salmon have shown that the critical periods for olfactory imprinting occurred between hatch through swimup and again at the smolt stage (Scholz et *al.* 1992, 1993; Tilson et *al.* 1994, 1995, 1996). These reports also indicated that imprinting coincided with elevated thyroxine levels (Scholz et *al.* 1993; Tilson et *al.* 1994, 1995). In these experiments, fish were exposed to synthetic chemicals in 1992 and 1993 at various developmental stages and behavioral tests were conducted in 1993 and 1994 with sexually mature fish (Tilson *et al.* 1994, 1995). The mature adults were released into a stream below a natural Y-maze with traps located at each arm of the maze at the upstream end. The fish could then choose which fork of the Y they preferred. Results suggested that imprinting coincided with elevated thyroxine levels.

Figure 1. Location of Lake Roosevelt kokanee hatcheries operated by Spokane Tribe and WDFW.



Inset shows location where fish stocks were obtained (Lake Whatcom Hatchery and Lake Roosevelt at Little Falls Dam).

Table 1. **Summary of coded wire tagged kokanee salmon exposed to synthetic chemicals released from 1992 - 1996 and recovered from 1993 - 19%.**

Cohort	Year of Release	Life stage at Release	Life stage Exposed	Year of recapture at age		
				2	3	4
1990	1992	Smolt	Smolt	--	1993	1994
1991	1992	Fry	Eyed egg	1993	1994	1995
			Hatch	1993	1994	1995
			Alevin	1993	1994	1995
			Swimup	1993	1994	1995
			Fry (Feb-Jul)	1993	1994	1995
1991	1993	Smolt	Smolt	1993	1994	1995
1992	1993	Fry	Eyed egg	1994	1995	1996
			Hatch	1994	1995	1996
			Alevin	1994	1995	1996
			Swimup	1994	1995	1996
			Fry (Feb-Jul)	1994	1995	1996
1992	1994	Smolt	Hatch	1994	1995	1996
			Alevin	1994	1995	1996
			Swimup	1994	1995	1996
1993	1994	Fry	Hatch-Swimup	1995	1996	1997
		Fry	Alevin-Swimup	1995	1996	1997
1993	1995	Smolt	Hatch-S wimup	1995	1996	1997
			Alevin-Swimup	1995	1996	1997
			Hatch-Swimup and Smolt	1995	1996	1997
			Alevin-Swimup and Smolt	1995	1996	1997
1994	1995	Fry	Hatch-Swimup	1996	1997	1998
			Alevin-Swimup	1996	1997	1998
1994	1996	Smolt	Hatch-Swimup and Smolt	1996	1997	1998

For example, fish which displayed peaks in whole body thyroxine levels at swimup, also displayed >65% homing as mature 2 and 3 year olds. This contrasted with fish exposed to synthetic chemicals at pre-hatch and post-swimup stages which had low thyroxine levels and displayed <30% homing when tested as mature adults. In yearling fish, plasma thyroxine peaked in early spring at the smolt stage (Scholz et *al.* 1992, 1993; Tilson et *al.* 1994). When these fish were-tested as mature adults, they displayed 59% homing as 3 year olds (Scholz et *al.* 1992, 1993; Tilson *et al.* 1994).

To determine if the results in these behavioral experiments could be duplicated in the field (Lake Roosevelt), most of the fish which were imprinted at different life stages were marked with an adipose clip and a distinctive coded wire tag (CWT) that uniquely identified: (1) exposure chemical, (2) life stage exposed, (3) release location, (4) life stage released, and (5) date released. A total of 1,651,325 coded wire tagged fish were released into Lake Roosevelt from 1992 to 1995. These fish either became or will become sexually mature spawners from 1994 to 1998. Field tests in Lake Roosevelt were conducted to estimate the following information for each group of coded wire tagged fish: (1) number entrained from Grand Coulee Dam, (2) number harvested by anglers in Lake Roosevelt; (3) number homing to egg collection sites scented with the appropriate imprinting chemical, and (4) number straying to other locations.

1.1 Study Strategy

The field tests were initiated in 1994. Fish which had been imprinted with synthetic chemicals at different life stages and coded wire tagged/adipose fin clipped, were released into Lake Roosevelt from 1992 to 1994. Chemical drip stations were set up at Sherman Creek Hatchery and on the Spokane River at Little Falls Dam to attract spawning kokanee salmon from mid July to late November 1994. Results from initial field imprinting investigations indicated that less than 1% of the total recoveries (3 of 431 recaptures) were fish released as CWT fry (n=375,780). Greater than 99% of the total recoveries (427 of 43 1 recaptures) came from fish released as (l+) smolts (n=211,654) (Tilson *et al.* 1994, 1995).

In 1995 and 1996, management practices were changed to release more kokanee salmon post-smolts into Lake Roosevelt. All fish released in 1996 were adipose clipped. These fish were imprinted at hatch-swimup or hatch-swimup and smolt stages. In the present study, we examined the results of coded wire tagged kokanee salmon returns to determine if the new management practices were conducive to increased returns to egg collection sites, decreased entrainment and increased harvest. The following tasks were completed in 1996:

(1) Lake Whatcom stock sub-yearling (1995 cohort) kokanee salmon were exposed to synthetic chemicals from hatch to swimup stage from January to February 1996. Yearling (1994 cohort) kokanee were exposed to synthetic chemicals at the smolt stage from April through May 1996. The odor delivery system was set up and monitored.

(2) Synthetic chemical drip stations were set up and monitored at Sherman Creek Hatchery and Little Falls Dam to attract spawning kokanee salmon from mid July to late November 1996.

(3) Kokanee salmon coded wire tag data was compiled and analyzed from the year-long creel surveys conducted by the Spokane Tribe of Indians (STOI), Colville Confederated Tribes (CCT) and Washington Department of Fish & Wildlife (WDFW). Coded wire tags were collected and analyzed from the regularly scheduled electrofishing surveys (conducted by STOI) as well as augmented electrofishing surveys (conducted by EWU) in the fall to estimate the number returning to egg collection sites at Sherman Creek and Little Falls and the number straying to other locations.

(4) Kokanee salmon entrainment from Grand Coulee Dam was monitored at Rocky Reach Dam and at Rock Island Dam. Any adipose clipped kokanee salmon outmigrants were collected during the smolt monitoring season (4-l-96 to 11-30-96) and biologists at these facilities froze the fish heads so we could check for coded wire tags.

(5) Kokanee salmon returns to egg collection sites were monitored by augmenting ST0i electrofishing surveys at Little Falls Dam and Sherman Creek during the spawning season. Augmented surveys were conducted by EWU biologists and student volunteers. Additionally, EWU monitored kokanee salmon returns at Big Sheep Creek, Colville River, Blue Creek, Hawk Creek, and Barnaby Creek.

(6) Recommendations were made about which life stages to imprint fish and about which release locations and dates that would (a) reduce entrainment from Grand Coulee Dam, and/or (b) increase harvest rates in Lake Roosevelt and/or (c) increase returns of adults to egg collection sites.

2.0 METHODS AND MATERIALS

2.1 Rearing Conditions

Kokanee salmon eggs reared at the Spokane Tribal Hatchery near Wellpinit, WA were obtained from two sources: 1) Lake Whatcom stock eyed eggs transferred from the Lake Whatcom Hatchery in Bellingham WA (WDFW); and 2) spawn take from Lake Roosevelt stock kokanee salmon. Lake Roosevelt stock were considered fish which had been planted in Lake Roosevelt and had returned to spawn. Water supply to the raceways was a combination of Metamooteles Springs water and well water at 8-1 l°C. After swimup, fry were feed trained on Biodiet semi-moist mash (starter feed). Older fry were fed a combination of Biodiet semi-moist grower feed (1.0 - 2.5 mm crumbles) and Silvercup size l-4 mm crumbles. Yearling fish were fed Biodry 1000 pellets (3.0 - 4.0 mm) obtained from Bioproducts, Inc. Photoperiod was maintained at natural daylength as each raceway was partially exposed to natural conditions of light and weather.

2.2 Olfactory Imprinting Investigations

From 1992 to 1994, kokanee salmon were exposed to either morpholine (C_4H_9NO at 5 x 10^{-5} mg/l) or phenethyl alcohol ($C_8H_{10}O$ at 5 X 10^{-3} mg/l) at various developmental stages (Tilson *et al.* 1994). Fish from each group were stocked at Sherman Creek and the Spokane River. During the spawning season morpholine was metered into Sherman Creek and phenethyl alcohol was metered into the Spokane River at Little Falls Dam to attract spawning kokanee salmon. During these years, the null hypothesis stated, "There was *no difference in the distribution offish exposed to different odors at a selected life history stage."* This result would have indicated that the fish did not imprint to their exposure odor at that developmental stage. This hypothesis was supported if migrating adults were captured at sites scented with their exposure odor and alternate odor in about equal numbers, which would have indicated that the fish selected sites randomly instead of being attracted to the site scented with their exposure odor. The alternate hypothesis stated, *"There is* a *difference in the distribution of fish exposed to different odors at a selected life history stage."* This result implied that fish did imprint to their exposure odor. This hypothesis was supported if fish were captured more frequently at sites scented with their exposure odor compared to sites scented with their alternative odor or sites not scented at all. Two imprinting chemicals were employed in this experiment so that one odor could act as a control for the other. That way, both groups would be treated exactly the same with the exception of the exposure chemical.

From 1992 to 1994, the alternative hypothesis was supported if morpholine exposed fish released at different sites homed to morpholine at Sherman Creek and phenethyl alcohol exposed fish released at different sites homed to phenethyl alcohol at Little Falls Dam. During these years, results did, in fact, indicate that chemically exposed fish released at different sites chose their appropriate imprint chemical instead of the alternative chemical or their release site (Scholz *et al.* 1993; Tilson et *al.* 1994).

In 1995 and 1996, the Lake Roosevelt kokanee salmon hatchery managers decided to drip both morpholine and phenethyl alcohol into Sherman Creek to attract as many adult spawners as possible to that site. Phenethyl alcohol was also metered into the Spokane River at a site in the tailrace of Little Falls Dam during these years. It was also decided that all morpholine exposed fish would be released only at Sherman Creek. This effectively ruined the homing experiments because: (1) we could no longer determine whether fish were imprinting to exposure chemicals or release sites; (2) we could no longer determine which chemical fish were attracted to at Sherman Creek and (3) there was no longer a control because morpholine exposed fish were released at only one location and phenethyl alcohol was metered at two different locations. To salvage the homing experiments, we calculated homing based on the number of chemically exposed fish returning to exposure chemicals compared to the, number returning to other sites.

Most fish released in 1996 were "double imprinted," initially at the hatch through swimup stages in 1995 *(i.e,* alevin) and a second time at the smolt stage in 1996. These fish received the double imprint because our earlier investigations had demonstrated that both the alevin/swimup and smolt stages were sensitive periods for imprinting (Tilson et *al.* 1994, 1995). In salmonids, the behavioral threshold detection limits were approximately 1 x 10^{-6} mg/l for morpholine (MOR) and 1 x 10^{-4} mg/l for phenethyl alcohol (PEA) (Scholz *et al.* 1975). Details of the synthetic chemical imprinting procedure and methods for calculating steady state concentration of imprinting chemicals were described in a previous annual report (Scholz *et al. 1993).*

2.3 Coded Wire Tagging Program

From 1992 to 1996, kokanee salmon were exposed to synthetic chemicals, and released into Lake Roosevelt at various locations (Appendix B, C). A portion of each group released were tagged with distinctive coded wire tags.

For marking experiments, kokanee salmon were dipnetted out of hatchery raceways and mildly anesthetized with a, 50 mg/l concentration of tricaine methanesulfonate (MS-222). Coded wire tags were then injected into the rostrum using a model MK4 CWT machine (Northwest Marine Technology, Inc.), equipped with two different nose hoods specially fitted for fry and fingerling-sized fish. Fish were given unique tag numbers based on imprinting history and release site. Lengths and weights of fingerlings which were marked for release in 1996 ranged from 73 to 98 mm and 3.3 to 7.8 g respectively. Lengths and weights of smolts ranged from 144 to 166 mm and 24.9 to 38 g respectively (Appendix A). All hatchery fish were given an adipose fin clip as an external identification mark. Marked fish were counted using a tally counter, then released back into hatchery raceways through a quality control device (QCD) (Northwest Marine Technology, Inc.) equipped with a CWT detector. The fish were retained for approximately three weeks before release to estimate mortality rates and tag retention. In 1996, mortality rates were uniformly low during the three week retention period (<l%) (T. Peone, Spokane Tribal Hatchery, personal communication). The mean percent tag retention after 20 days was 94.5%, and ranged from 75 to 98% (Appendix A). Long term tag retention (approximately three months in reservoir) was estimated at 74%. This was calculated as the total number of adipose clipped fish recovered without CWT's divided by the total number of CWT fish recovered.

Reservoir wide creel surveys were conducted throughout the year by individuals from the Spokane Tribe, Colville Confederated Tribe, and the Washington Department of Fisheries and Wildlife (Cichosz et *al.* this report). Electrofishing/gill net surveys and EWU augmented electrofishing surveys were conducted during the spawning season (September-November, 1996). These augmented electroshocking surveys were done seven days in September (9/4 to 9/27), ten days in October (10/2 to 10/30) and seven days in November (1 l/l to 1 l/15) at various locations in the reservoir and concentrated at Little Falls Dam and Sherman Creek. Additional trips in November were planned, but an ice storm followed by hazardous ice and snow conditions 'precluded monitoring beyond 1 l/15 in 1996. Additionally, WDFW personnel at Sherman Creek Hatchery monitored a ladder trap during the spawning season. Sherman Creek above the hatchery ladder was fished via backpack electroshocker two days in October, three days in November and one day in December. In December, a gill net was set in Sherman Creek cove and monitored by WDFW personnel.

Heads were removed from all kokanee salmon with adipose clips and sent to the Upper Columbia United Tribes Fisheries Research Center at Eastern Washington University, where, CWT's were recovered and examined with a dissecting microscope to determine the binary code. The number of fish from each lot returning to Sherman Creek, Little Falls Dam, and other locations was determined.

Percent error of coded wire tags read was determined by having two individuals read 17% of the tags. If there was a discrepancy on a tag code, both people re-read those tags until they were in agreement. In 1996, a total of 1,555 adipose clipped fish were examined for coded wire tags. There were 1,229 heads which contained tags. However, 1.4% (n=17 tags) were lost in the extraction process. After Reader 1 and Reader 2 read the tags, there was a discrepancy on 7 of 2 11 tag codes for an error of 3.3%. Reader 2 was incorrect on 3/211 tags for a 1.4% error.

In order to collect coded wire tagged fish below Grand Coulee Dam, we coordinated efforts with the Fish Passage Center's Smolt Monitoring Program at both Rocky Reach Dam (three dams downstream from Grand Coulee Dam) and at Rock Island Dam (four dams down from Grand Coulee Dam) to collect kokanee salmon outmigrants from April 1 to November 30, 1996. At Rocky Reach Dam, we had technicians examine adipose clipped kokanee salmon of any size. At Rock Island Dam, we had technicians look for adipose clipped kokanee salmon which were 250 mm or larger. The reason for the size differentiation was because Lake Wenatchee net pen sockeye salmon were also adipose clipped and coded wire-tagged. It would not be possible to separate the adipose clipped age l+ Lake Roosevelt kokanee salmon from adipose clipped age l+ anadromous sockeye passing Rock Island Dam without sacrificing both species. Other dams (including McNary, John Day and Bonneville Dam on the Columbia River) were contacted at the end of the year to determine if there were any large kokanee salmon (>250 mm) observed in their fish passage facilities. The larger kokanee salmon (>250 mm) would have been 2 to 4 year old fish which had remained in one of the reservoirs after release until they migrated downstream or had been entrained as subadults.

2.4 Statistical Analysis

We used a chi-squared test to test the null hypothesis (H_0) *"There was no difference in the distribution of fish exposed to different odors '.* If the calculated probability was greater than 0.05 ($p > 0.05$), then we interpreted this to mean that fish were not attracted to their exposure odor. If $p \leq 0.05$, then we accepted *the* alternative hypothesis (HA), *'There is a difference in the distribution of fish exposed to different odors. Chemically exposed fish moved to streams scented with their exposure chemical in greater numbers than they did to other streams. "* A statistical significance would imply that the fish were homing to their exposure odor.

Data was presented as percent homing and percent recovered. Percent homing (p) was defined as:

$$p = h/(h+s) * 100$$

where:

p = percent homing (%)

h = number homing to exposure odor (exposed fish) or release site (unexposed fish); and

s = number straying to other locations.

Percent recovered was defined as the number of fish recovered at a specific location divided by the total number of fish recovered in Lake Roosevelt in 1996.

3.0 RESULTS

3.1 Kokanee Salmon Releases and Recoveries

From 1992-96 a total of 5,809,536 kokanee salmon were released into Lake Roosevelt, of which 1,185,691 were tagged with CWT/fin clips and considered recoverable in 1996. Recoverable fish included kokanee salmon which could be positively identified with coded wire tags and/or fish which were 2-4 years old. Total coded wire tag releases included 335,867 fry and 849,825 sm0lts (Table 2). Kokanee salmon in Lake Roosevelt attain lengths of about 250 400 mm by age 2 and spawn principally at age 2, age 3 and sometimes age 4. A portion of the total number of coded wire tagged fish (87%), including 325,737 fry and 706,746 smolts, were Lake Whatcom stock fish that had been exposed to either morpholine or phenethyl alcohol. The remaining fish, including 10,130 fry and 143,078 smolts (13%) were not exposed to any chemical and were from the Lake Roosevelt stock (Table 2).

Recoveries of kokanee salmon captured in gill nets or traps, or by electrofishing, hook & line and creel surveys in 1996 are shown in Table 3. A total of 1,597 fish were recovered. Most fish were recovered in fish surveys (n=1,588) including gill netting (n=34), hook & line (n=2), traps (n=81) and electroshocking (n=1,471). Many of these fish were recovered during their fall spawning migration at sites scented with synthetic chemicals, including 420 at Sherman Creek and 215 at Little Falls (Table 3). Nine kokanee salmon were recovered by creel surveys, none of which were adipose clipped. Of the total number of fish recovered, 97% (n=1,548) were adipose fin clipped.

In 1996, 99.7% (1,210 of 1,213) of the coded wire tagged recoveries were age 2 jacks or jills while 0.3% (3 of 1,213) were age 3 (Table 4). In comparison, 96% of the total coded wire tagged recoveries were 2 year old jacks or jills in 1995 and 57% were 2 year olds in 1994. We realize 2 year olds are undesirable for spawn take. However, we analyzed all ages together for imprinting results since our prior experiments had shown that 2 and 3 year olds demonstrated similar homing tendencies (Tilson et al. 1994, 1995).

3.1.1 Imprinted Releases and Recoveries

From 1993 to 1996, Lake Whatcom brood stock releases (chemically imprinted) included 325,737 fry and 706,746 smolts. These fish could have been recovered as 2, 3 or 4 year olds in 1996 (Table 1). Our results include recoveries from 1995 and 1996 since only 4% of the recoveries were made prior to 1995. A total of 2,389 CWT/fin clipped fish were recaptured in 1995 and 1996 including 1,481 recaptured at egg collection sites at Sherman Creek and Little

Table 2. **Number of recoverable coded wire tagged (1992 to 1994 cohort) kokanee salmon released into Lake Roosevelt from 1993 through 1996[1].**

Synthetic Chemical Exposed - Lake Whatcom brood

Stage at Release	1993	1994	1995	1996
fry	204,328	69,998	51,411	0
smolt	n/a[2]	108,602	255,851	342,293

Unexposed - Lake Roosevelt brood

Stage at Release	1993	1994	1995	1996
fry	0	10,130	0	0
smolt	n/a[2]	22,584	66,531	53,963

1 These numbers represent kokanee salmon that CM be positively identified with coded wire tag data codes which have not been duplicated.

2 These fish were not recoverable because they would exceed the life expectancy of kokanee salmon in Lake Roosevelt.

Table 3. Kokanee salmon recoveries in Lake Roosevelt by eiectrofishing, gill net, hook & line, trap and creel surveys from January through December 1996.

Location	Fish Surveys Total No. Recovered	Fish Surveys Total No. Adipose Clipped	Creel Surveys Total No. Recovered	Creel Surveys Total # Adipose Clipped	Grand Totals Total No. Recovered	Grand Totals Total # Adipose Clipped
1 Kettle Falls[1]	420	416	0	0	420	416
2 Gifford[1]	6	3	0	0	6	3
3 Hunters	12	10	0	0	12	10
4 Porcupine Bay[1]	248	245	0	0	248	245
5 Little Falls	215	204	0	0	215	204
6 Seven Bays[1]	663	658	0	0	663	658
7 Kellers Ferry	0	0	3	0	3	0
8 San Poil	9	2	0	0	9	2
9 Spring Canyon	15	10	6	0	14	8
TOTALS	1,588	1,548	9	0	1,597	1,548

1 Kettle Falls includes Sherman Creek, Gifford location includes Bamahy Creek, Porcupine Bay includes Blue Creek and Seven Bays locatiou includes Hawk Creek.

Table 4. **Number of age 2 (jacks or jills), 3, and 4 year old coded wire tagged kokanee salmon recovered from 1992 through 1996.**

Year Recovered	Age 2	Age 3	Age 4
1992	87	none expected	none expected
1993	166	6	none expected
1994	52	33	7
1995	1,169	46*	3
1996	1,210	3	0

* In 1995 there were an additional 250 fish presumed to be age 3 which were lost to otter predation.

Falls Dam/Spokane River (Tables 5-7). During the past two years, there were only three recoveries of fish which had been stocked as fry.

In 1995 and 1996, a total of 479 (74%) morpholine-exposed fish (released at the smolt stage) were recovered as adult spawners at Sherman Creek (morpholine scented) compared to 42 (6%) recovered at Little Falls Dam (phenethyl alcohol scented) and 132 (20%) at other locations (Tables 5-7). In contrast, 770 (67%) phenethyl alcohol exposed fish were recovered at phenethyl alcohol scented waters (Spokane River and Sherman Creek) while 379 (33%) were recovered at other locations (Tables 5-7).

3.12 Unexposed Releases and Recoveries

Fish recovered as 2, 3 or 4 year olds in 1995 and 1996 would have been released from 1993 to 1996 as smolts (Table 1). In 1995, there were 37,654 unexposed coded wire tagged fish released in the Spokane River as yearlings with a total of 244 recovered as 2 year olds in l995. There were not any 3 or 4 year olds recovered in 1996 (Table 5,6).

Of the 21,534 unexposed fish which were released in Barnaby Creek as smolts in 1995, a total of 199 fish were recovered in 1995 and 1996 (Table 6). In 1996, only two of these fish were recovered as 3 year olds while 197 were recovered in 1995 as 2 year old jacks and jills (Tables 5,6).

Of the 29,927 unexposed fish released from the Kettle Falls Net Pen as smolts in 1994 and 1995, a total of 6 fish were recovered in 1995 as 2 year olds (Table 6,7). There were no 3 year olds recovered% 1996.

Of the 53,963 unexposed fish released from the Two Rivers Net Pen at the mouth of the Spokane River in 1996, a total of 113 fish were recovered as 2 year olds in 1996. Of these, 20% (n=23) were recovered in the Spokane River, 75% (n=85) were recovered at Hawk Creek and 2% (n=2) were recovered at Sherman Creek (Table 5).

Table 5, **Recoveries by location of coded wire tagged kokauee salmon from releases made in 1996. Recoveries are total number recovered from creel and fisheries surveys conducted in 1996.**

Cohort	Stages Exposed	Exposure Odor	Release Location	Life Stage At Release	CWT/Ad clip Released (n)	Ad clip only Released (n)	CWT recoveries Sherman Cr (MOR/PEA) (n)	Spokane R (PEA) (n)	Hawk (n)	Barnahy (n)	Other (n)
1994		NONE	Two Rivers Net Pen[1]	Smolt	53,963	4,189	2	23	85	0	3
1994	Hatch-swimup	MOR	Two Rivcrs/ Hall Cr Net Pen[1]	Smolt	31,441	758	2	20	37	0	I
1994	Hatch-swimup and Smolt	PEA	Barnaby Creek[2]	Smolt	14,290	758	1	16	29	0	2
		PEA	Spokane River	Smolt	36,177	3,960	8	253	253	0	8
1994	Ilatch-swimup	MOR	Kettle Falls Net Pen[3]	Smolt	61,897	2,875	5	4	9	0	0
1994	Hatch-swimup and smolt	MOR	Sherman Creek	Smolt	128,848	7,148	256	13	48	1	4
		PEA	Sherman Creek	Smolt	69,640	4,865	67	19	29	0	3

1 The Two Rivers Net Pen is located at the mouth of the Spokane River. Ha11 Creek is located north of Gifford Ferry.
2 Barnaby Creek is located approximately 11 miles south of Sherman Creek.
3 The Kettle Falls net pen is located at the Kettle Falls Marina.

Table 6. **Recoveries by location of coded wire tagged kokanee salmon from releases made in 1995. Recoveries are total number recovered from creel and fisheries surveys conducted in 1995 and 1996[1].**

Cohort	Stages Exposed	Exposure Odor	Release Location	Life Stage At Release	CWT/Ad clip Released (n)	Ad clip only Released (n)	CWT recoveries: Sherman Cr (MOR/PEA) (n)	Spokane R (PEA) (n)	Hawk Cr (n)	Barnaby (n)	Other (n)	Dam[4] (n)
1994	Hatch-swimup	MOR	Sherman Creek	Fry	40,468	3,708	0	0	0	0	0	0
1994	Alevin-swimup	MOR	Chamokane Creek	Fry	10,943	386	0	0	0	0	0	0
1993	--	NONE	Barnaby Creek[2]	Smolt	21,534	625	1	56	96	43	2	1
	--	NONE	Spokane River	Smolt	37,654	987	5	80	133	26	0	I
	--	NONE	Kettle Falls Net Pen[3]	Smolt	7,343	429	5	0	1	0	0	I
1993	Hatch-swimup	MOR	Kettle Falls Net Pen	Smolt	17,103	1,097	11	0	0	2	0	I
		PEA	Kettle Falls Net Pen	Smolt	23,183	1,283	6	0	1	1	0	1
1993	Alevin-swimup	MOR	Kettle Falls Net Pen	Smolt	2 1,068	912	4	0	0	0	1	1
1993	Hatch-swimup and smolt	MOR	Sherman Creek	Smolt	16,576	280	110	2	12	4	-2	0
		PEA	Sherman Creek	Smolt	124,906	6,398	390[i]	6	28	13	12	1
1993	Alevin-swimup and smolt	MOR	Sherman Creek	Smolt	51,455	2,088	109	3	3	5	3	1
		PEA	Sherman Creek	Smolt	1,560	20	4	0	0	0	0	0

1 An additional 160,000 1994 cohort fry were released into Sherman Creek in 1995. These fish were unmarked and unexposed. Fish from the 1994 cohort are expected to return in 1996, 1997 and 1998 as 2, 3 and 4 year olds respectively. Fish from the 1993 cohort returned as age 3 in 1996.

2 Barnaby Creek is located approximately 11 miles south of Sherman Creek.

3 The Kettle Falls net pen is located at the Kettle Falls Marina.

4 Fish recoveries from Dams, were from the smolt passage facilities at Rock Island or Rocky Reach Dams in 1996.

5 One of these fish was collected in 1996 as a 3 year old.

i Two of these fish were collected in 1996 as 3 year olds.

Table 7. **Recoveries by location of coded wire tagged kokanee salmon from releases made in 1994. Recoveries are total number recovered from creel and fisheries surveys conducted in 1995 and 1996.**[1]

Cohort	Stage Exposed	Exposure Odor	Release Location	Life Stage At Release	Total # CWT Released	# recovered at: Sherman Creek (MOR[2])	# recovered at: Spokane River (PEA)	# recovered at: Hawk Creek	# recovered at: Other
1992	Hatch	MOR	Shennan Creek	Smolt	10,613	0	0	0	0
		MOR	Blue Creek	Smolt	10,291	14	1	6	3
		PEA	Spokane River	Smolt	8,352	0	0	0	0
		PEA or MOR	Spokane River	Smolt	11,140	10	2	7	2
1992	Alevin	MOR	Sherman Creek	Smolt	15,523	1	0	0	0
1992	Swimup	MOR	Shennan Creek	Smolt	20,739	0	0	0	0
		PEA	Shennan Creek	Smolt	31,944	0	0	0	0
1992	--	NONE	Kettle Falls Net Pen	Smolt	22,584	0	0	0	O.
1993	Hatch through Swimup	MOR	Sherman Creek	Fry	20,261	0	0	0	0
		PEA	Sherman Creek	Fry	10,099	0	0	0	0
1993	Alevin through Swimup	MOR	Sherman Creek	Fry	18,696	0	0	0	0
		PEA	Sherman Creek	Fry	20,942	0	0	0	0
1993		NONE	Sherman Creek	F	10,130	3	0	0	0

1 The 1993 cohort fish were recovered at age 2 in 1995. There were no age 4 (1992 cohort fish) or age 3 (1993 cohort fish) recovered in 1996.
2 In 1995 and 1996. both MOR and PEA were dripped at Sherman Creek, PEA was also dripped into the Spokane River at Little Falls Dam.

3.2 Kokanee Salmon Entrainment

A total of 12 adipose clipped kokanee salmon (>250 mm) were collected from the Rock Island Dam fish passage facility and the Rocky Reach Dam Surface Collector (Table 8). Of these, eight were coded wire tagged. Coded wire tag analysis revealed that 75% (6 of 8) of the recoveries were fish released in 1995 from the Kettle Falls area (Sherman Creek or the Kettle Falls Net Pens). One was released in 1995 from Barnaby Creek and one fish was released from the Spokane River. AlI coded wire tagged fish were 3 year olds from the 1993 cohort. The average length of these fish recovered at the dams between April 24, 1996 and July 20, 1996 was 282 mm.

At Wanapum Dam, 32 large kokanee salmon (>200 mm) passed through the bypass system (Chris Carlson, Biologist, Grant County PUD, personal communication). At the McNary Dam Smolt Monitoring Program, 23 kokanee salmon (>200 mm) were seen from June 18 to November 5, 1996. Of these, 7 fish were either adipose clipped or vent clipped (Rosanna Tudor, WDFW Biologist, personal communication). The average length of these marked fish was 241 mm. These large fish are reported to the Washington Department of Fish & Wildlife as kokanee salmon *(Oncorhynchus nerka kennerlyi)* since they are larger than sockeye smolts. However, they are reported to the Fish Passage Center as sockeye *(0. nerka nerka)*. There is no way to currently determine the correct sub-species of these fish at the fish passage facilities. At the John Day Dam Smolt Monitoring Program, 5-10 large kokanee salmon (>200 mm) were observed in 1996 (Ritchie Graves, Site Biologist, Rufus Woods Field Station, National Marine Fisheries Service, personal communication).

3.3 Statistical Analysis

Results from chi-square tests revealed that there was a significant difference ($p < 0.05$) between fish recovered at their exposure scent and fish recovered at other sites (Table 9).

Table 8. **Recoveries of kokanee salmon from Rock Island Dam Smolt Monitoring Program and Rocky Reach Dam Surface Collector in 1996.**

Cohort	Release Size (mm)	Release Date	Release Location	Recovery Location	Recovery Date	Recovery Size (mm)	Binary #
1993	147	May 1995	Kettle Falls Net Pen	Rock Island Dam	4/24/96	285	62-52-40
1993	160	June 1995	Kettle Falls Net Pen	Rock Island Dam	4/27/96	256	62-53-57
				Rock Island Dam	5/5/96	272	NO TAG
				Rock Island Dam	5/6/96	277	NO TAG
1993	160	June 1995	Kettle Falls Net Pen	Rock Island Dam	5/16/96	281	62-53-40
				Rock Island Dam	5/16/96	305	NO TAG
1993	173	June 1995	Sherman Creek	Rocky Reach S.C.	5/17/96		62-53-58
1993	177	June 1995	Sherman Creek	Rock Island Dam	6/8/96	291	62-53-49
				Rock Island Dam	6/26/96	252	NO TAG
1993	160	May 1995	Barnaby Creek	Rock Island Dam	6/28/96	290	62-51-26
1993	160	May 1995	Spokane River	Rock Island Dam	7/1/96	272	62-51-42
1993	147	May 1995	Kettle Falls Net Pen	Rock Island Dam	7/3/96	320	62-52-41.

Table 9. **Statistical comparison of the number (#) of kokanee salmon (1993-1994 cohort) released in 1995 and 19% and recovered in 1996 which were exposed to either morpholine (MOR) or phenethyl alcohol (PEA) and recovered at their exposure odor or other site. Degrees of freedom = 1.**

	No. Released (n)	No. Recaptured (n)	Return Exp. Odor (n)	Return to other (n)	Chi Square
MOR	328,388	410	263	137	$x^2 = 16.75$
PEA	269,756	690	366	324	$p < 0.05$

4.0 DISCUSSION

This study has important implications for management of the Lake Roosevelt kokanee salmon fishery. The results of the CWT investigations continue to show that kokanee salmon can be successfully imprinted to artificial odors - morpholine and phenethyl alcohol - as juveniles. Results suggest that chemical exposure as well as release site play an important role in homing. In addition, results of the present study continue to support results of previous investigations which show that: 1) fish “double exposed” to synthetic chemicals at alevin/swimup and smolt stages had a high rate of homing to egg collection sites; and 2) fish released at the smolt/residualized smolt stage were recovered in greater numbers at egg collection sites than fish released as fry (Tilson et *al.* 1994, 1995; 1996). Even though most of these recoveries were from age 2 jacks and jills, the information will be helpful in continuing to develop management strategies for the Lake Roosevelt kokanee salmon fishery.

4.1 Imprinting Investigations

Results of previous laboratory and field imprinting investigations showed that chemical imprinting coincided with elevated thyroxine levels (Scholz et *al.* 1993, Tilson et al. 1994, 1995). The groups that had the highest whole body thyroxine content also had the highest percentage of fish that were reliably attracted to their exposure odor as sexually mature 2 or 3 year old adults in behavioral tests conducted in a Y-maze in 1993 and 1994 (Scholz et al. 1993, Tilson et *al.* 1994). In the Y-maze experiments imprinted fish were released downstream from natural Y One fork of the Y was scented with phenethyl alcohol and the other with morpholine. Fish could then choose the fork they preferred.

To determine if these controlled field experiments could be duplicated in the field (Lake Roosevelt), experiments were initiated in 1992 in Lake Roosevelt with coded wire tagged fish which were imprinted at different life stages to either morpholine or phenethyl alcohol with each group of chemically exposed fish being released at at least two different sites. Results of CWT investigations prior to 1995 indicated that fish exposed at hatch, swimup and smolt stages exhibited the greatest degree of homing (Tilson et *al.* 1995). In both 1995 and 1996, most fish were exposed from the hatch through swimup stage or from the hatch through swimup and smolt stages. All of the fish exposed at the hatch to swimup stage only, were released from net pens in Lake Roosevelt as yearlings. Of the 78 fish recovered in 1996 which were exposed to synthetic chemicals from hatch to swimup, only 7 fish (9%) were recovered at the correct chemical site. All of these fish were age 2. One reason for the low recovery of net pen releases may be that fish were released in April or May due to drawdowns in the reservoir and the inability to hold them longer. Prior studies have shown that kokanee salmon are at the peak of smoltification in April and May (Tilson *et al.* 1994, 1995). These fish may be experiencing an increased urge to migrate downstream and may be being entrained from Grand Coulee Dam. Recoveries from net pen releases have been poor. In 1995 and 1996, only 107 total chemically imprinted fish were recovered in Lake Roosevelt out of 154,692 fish released from net pens. A large percentage of the fish that did not home were recovered at Hawk Creek, which is 6.9 km south of the Spokane River. Hawk Creek has been an attractive site for kokanee salmon on their spawning migration in recent years (See Section 4.1.2 for more discussion of Hawk Creek).

Fish which were imprinted at hatch through swimup and again at the smolt stage were termed "double exposed". Morpholine exposed fish displayed 64% homing and phenethyl alcohol exposed fish displayed 53% homing. The number of fish homing to their exposure chemical was significantly higher than those not homing to their exposure chemical (Table 9). This reinforces the idea that kokanee salmon have a critical period early in development from hatch to swimup and a second critical period at the smolt stage in which imprinting occurs.

4.1.1. Homing of Exposed vs. Unexposed Fish

Fish exposed to synthetic chemicals were recovered in greater numbers (% recovered) and displayed higher homing ability (% homing) to egg collection sites than fish that were not exposed to synthetic chemicals (Table 10). For example, of the 47 1,804 chemically exposed kokanee yearlings released at Sherman Creek, 1,148 fish were recovered in Lake Roosevelt in 1995 and 1996 for a recovery rate of 0.2% Of the 1,148 fish recovered, 962 homed correctly to their exposure odor (84% homing). It was not possible to compare homing of unexposed fish, because all releases were from fry plants. We are currently conducting a study which directly addresses the issue of exposed vs. unexposed fish return rates and homing ability. In this study, a group of unexposed fish and a group of fish exposed to morpholine from hatch to swimup will be transferred to Sherman Creek Hatchery as fingerlings in April 1998 and released from Sherman Creek in July 1998. Percent homing and percent recovery will be monitored in the autumn of 1998,1999 and 2000. This will allow us to determine if chemical imprinting is necessary for fish released as post-smolts from Sherman Creek Hatchery.

Table 10. **Summary of chemically exposed - v - unexposed coded wire tagged/fin clipped kokanee salmon (1991-1994 (cohorts) homing to exposure odor or release sites in 1995 and 1996.**

Release Location	# Released			# Recovered		% homing[2]	% recovered[3]
	Fry	Smolt	Total	@ home stream[1]	@ other locations		
Sherman Creek							
Chem Exposed	217,738	471,804	689,542	962	186	84%	0.2%
No Chem	10,130	0	10,130	3	0	100%	0.3%
Spokane River							
Chem Exposed	75,272	55,669	130,941	273	270	50%	1.0%
No Chem	0	37,654	37,654	80	164	33%	0.6%
Blue Creek							
Chem Exposed	0	10,291	10,291	14	10	58%	0.2%
No Chem	0	0	0	0	0	n/a	n/a
Barnaby Creek							
Chem Exposed	21,784	14,290	36,074	17	37	35%	0.3%
No Chem	0	21,534	21,534	43	155	22%	0.9%
Kettle Falls Net Pens							
Chem Exposed	0	123,251	123,251	26	18	59%	0.3%
No Chem	0	29,927	29,927	0	6	0%	0.02%

1 Home stream = Recovered at stream scented with expsosure odor (chemically exposed fish) or Release site (unexposed fish).
2 Percent homing = total number captured at exposure odor or release site (home stream) + total number recovered in Lake Roosevelt.
3 Percent recovered = total number recovered + total number smolts released (since >99% of fish returning were from fish released as smolts).

At the Spokane River, 55,669 chemically exposed fish were released as smolts. Of these, 543 fish were recovered in Lake Roosevelt for a recovery rate of 1% (Table 10). Of the 543 fish recovered, 273 homed correctly to their exposure chemical (50% homing). In contrast, 37,654 unexposed fish were released into the Spokane River. Of these, 244 fish were recovered for a recovery rate of 0.6% (Table 10). Of the 244 fish recovered, 80 homed correctly to the site of release (33% homing).

In Blue Creek, 10,29 1 chemically exposed fish were released as yearlings. Of these, 24 fish were recovered in Lake Roosevelt for a recovery rate of 0.2% (Table 10). Of the 24 fish recovered, 14 homed correctly to their exposure chemical (58% homing). There were no unexposed fish released at Blue Creek in which to compare homing.

At Barnaby Creek, 14,290 chemically exposed fish were released as yearlings. Of these, 54 fish were recovered in Lake Roosevelt for a recovery rate of 0.3% (Table 10). Of the 54 fish recovered, 17 homed correctly to their exposure chemical (35% homing). In-contrast, 21,534 unexposed yearlings were released into Bamaby Creek. Of these, 198 fish were recovered in Lake Roosevelt for a recovery rate of 1.0%. Of the 198 fish recovered, 43 homed correctly to the site of release (22% homing). Effort in Bamaby Creek was dramatically lower in both 1995 and 1996 than effort at other sites. In 1995, Bamaby Creek was shocked for 19 minutes on 1 day. During 1996, it was shocked for 25 minutes over 2 days and a gillnet was set for 1 day during the spawning season. We feel Bamaby Creek is unsuitable for kokanee salmon spawners because of poor water conditions (cow pastures, shallow, slow water at the mouth) access problems (beaver dams, culvert) and predators (walleye congregate at the mouth of the creek). All kokanee salmon caught at the mouth of Bamaby Creek in 1996 had injuries that may have been caused by walleye.

Of the 123,251 chemically exposed fish released as yearlings from the Kettle Falls net pens, 44 were recovered in Lake Roosevelt for a recovery rate of 0.04% (Table 10). Of the 44 fish recovered, 26 homed correctly to their exposure chemical (59% homing). In contrast, 29,927 unexposed yearlings were released from the Kettle Falls Net Pens. Of these, 6 fish were recovered in Lake Roosevelt for a recovery rate of 0.02%. Of the 6 fish recovered, none homed correctly to the site of release (0% homing). However, 5 of 6 unexposed fish were recovered at Sherman Creek cove which is less than 1 mile downstream from the net pen sites.

4.1.2 Homing to Release Site

Release site played an important role in the homing ability of kokanee salmon. Fish released as smolts at Sherman Creek in 1995 and 1996 displayed 74% homing to Sherman Creek in 1996. This was the highest percentage of homing of any group of fish released into Lake Roosevelt (Table 11). These fish were imprinted to synthetic chemicals and transferred to Sherman Creek as fry. It is possible that they imprinted to Sherman Creek water and/or synthetic chemicals at the smolt stage in the spring before release in July, which resulted in higher homing.

Imprinted and non-imprinted fish released in the Spokane River as smolts in 1995 and 1996 displayed 48% homing back to the Spokane River (Table 11). Straying rate was high for Spokane River releases (52%). A substantial number of kokanee salmon (both chemically imprinted and non imprinted) were recovered at Hawk Creek in 1995 and 1996. In 1995,23% (274 of 1,191) of the total kokanee salmon recovered were found in Hawk Creek. In 1996,41% (490 of 1,201) of the total kokanee salmon recovered were found at that site.

There are three potential explanations for the high numbers of kokanee salmon in Hawk Creek. Fish could have been attracted to Hawk Creek embayment in search of food. Even though zooplankton was not sampled in Hawk Creek, we observed food in the stomachs of kokanee during the fall, when determining the sex of the CWT fish. Previous investigators also found that some embayments of Lake Roosevelt had more zooplankton than the main reservoir (Nigro er *al.* 198 1, Beckman et *al.* 1985; Underwood et *al.* 1996). Although total zooplankton abundance was very similar in 1995 and 1996 in the main body of the reservoir, the abundance of *Duphnia spp.* (which is the preferred prey item of kokanee) was lower in 1996 than it was during the previous year (Cichosz et *al.* this report). The summer zooplankton increase was also delayed compared to previous years. Kokanee may have moved into Hawk Creek embayment to feed during the summer when plankton levels were lower in the main reservoir and stayed there during the early portion of the spawning season. Our data showed that fish recovered in September at Hawk Creek averaged 304 mm and 366 g, whereas in November, fish averaged 341 mm and 437 g. Collectively, these data suggest that growth occurred from September to November. However, it could be that larger fish were migrating to Hawk Creek later in the

Table 11. **Summary of recoveries of coded wire tagged kokanee salmon from yeariing releases made in 1995 and 1996 (1993 and 1994 cohort). Recoveries are total number of age 2 and age 3 fish[1] recovered from electrofishing surveys conducted in autumn 1996.**

				CWT Recovered at				
Release Location	**Month Released**	Total No. **Released**	**Total No. Recovered**	**Sherman Creek (n)**	**Spokane River (n)**	**Hawk Creek (n)**	**Barnaby Creek (n)**	**Other (n)**
Sherman Creek	July	392,985	442	325	32	77	1	7
Spokane River	June	73,654	522	8	253	253	0	8
Bamaby Creek	June	35,824	49	1	16	29	0	3
Spok. R Net Pen[2]	May	53,963	113	2	23	85	0	3
Kettle Falls Net Pen	April	130.594	18	5	4	9	0	0

1 Only three age 3 fish were recovered in 1996.
2 Spokane River Net Pen was located at the mouth of the Spokane River.

spawning season. It will be important to do limnological studies in Hawk Creek to determine zooplankton abundance. We also recommend initiating a mark/recapture study to determine the migration pattern of the kokanee salmon. By doing this, we will find out if kokanee are stopping in at Hawk Creek before continuing their spawning migration.

Another explanation could be that fish were moving out of the Spokane River because they did not sense their exposure odor. In 1996, there were long periods of time during the fall when no chemical was being dripped into the Spokane River at Little Falls Dam. Phenethyl alcohol was not dripped from September 2 - September 16, from September 23 - September 30 and from October 31 - December 15, 1996. During periods of time when no chemical was being dripped (6 weeks of the 11 week spawning season), fish could have moved out of the Spokane River to try to find their imprint odor somewhere else. In fact, of the 490 fish recovered at Hawk Creek in 1996,253 (51.6%) of were fish exposed to phenethyl alcohol and released in the Spokane River. Johnsen and Hasler (1980) investigated rheotropic responses (upstream or downstream swimming in response to exposure or imprint odor) in coho salmon imprinted to synthetic chemicals. They found that morpholine-imprinted fish moved upstream when morpholine was present and downstream when morpholine was absent. Also, Scholz et *al.* (1993) and Tilson et *al.* (1994) found that during Y-maze tests, kokanee salmon were recovered at the downstream weir on the days when no chemical was dripped. Therefore, if the fish did not sense their imprint odor, they could have moved downstream out of the Spokane River and ended up at Hawk Creek.

A third explanation for the abundance of kokanee salmon in Hawk Creek is that it is easier to recover fish by electroshocking in Hawk Creek than in the Spokane River. Hawk Creek is narrow, shallow and blocked by a waterfall about 3.6 km up from the mouth. It is easy to run the fish up to the falls and trap them. In contrast, the Spokane River is deep and the current swift. It is easier for fish to escape the electric current. There may be more fish moving into the Spokane River which are not being recovered. However, this is unlikely since we caught so many fish in the Spokane River in 1995. In 1996, we spent more time and caught less fish than in 1995. Catch per unit effort was 0.26 in 1996 compared to 0.44 in 1995 (Table 12). Thus we believe it is more likely that food availability or lack of imprint chemical in the Spokane River causing straying explains the large numbers of fish captured at Hawk Creek rather than differences in catchability at a particular location.

Table 12. Catch per unit effort (CPUE) for kokanee salmon recovered in the Spokane River by eiectrofishing from September 1 to November 30, 1995 and 1996.

Year	# kokanee salmon	# min	CPUE
1995	411	935.2	0.439
1996	459	1,766.8	0.260

Overall, release site and chemical imprinting seem to be very important components to adult recoveries. In addition, yearling (post-smolt) releases continued to provide better adult recoveries than fry releases. This could be because fish residualize at the hatcheries after smoltification (See Tilson *et al.* 1994, 1995 for more discussion on kokanee salmon smoltification). We did not release any fry in 1996 since there were only three recoveries of fish released as fry in previous years. However, even though we saw successful homing to release sites or exposure chemicals, the total recovery rate for kokanee salmon in Lake Roosevelt was still low (0.30%).

There are three possible explanations for the low number of recoveries of adult kokanee salmon. One explanation may be predation. Walleye predation is known to occur when kokanee salmon fry are released, as evidenced by observations of CWT kokanee salmon fry in stomachs of walleye collected at release sites (Thatcher *et al.* 1993). Additionally, walleye collected from the reservoir were occasionally reported containing salmonids, presumably kokanee salmon or rainbow trout in their stomachs (Peone et al. 1990; Griffith and Scholz 1991; Thatcher et *al.* 1993). There was evidence of large predator species such as burbot and walleye congregating at spawning areas in both 1995 and 1996. In 1995, we observed large walleye (range 500-720 mm and 4.2 kg) near schools of mature 2 year old kokanee salmon during their spawning migration. One of those walleye (685 mm, 4 kg) had swallowed a 2 year old adipose clipped kokanee salmon. In 1996, 188 burbot were observed in the Hawk Creek trap. Technicians reported seeing as many as 15% of these burbot with adult kokanee salmon in their guts, some with tails sticking out of their mouths (T. Peone, Spokane Tribal Hatchery Manager, personal communication). At Sherman Creek, one burbot (705 mm) had two coded wire tags in its stomach.

Although walleye and burbot prey on kokanee salmon opportunistically, we believe that only a predator greater than 550 mm could consume a 2 year old kokanee salmon. There were 15 burbot >550 mm and 4 walleye >550 mm reported at the Kettle Falls area and 5 walleye >550 mm reported at Little Falls Dam. We recognize that predation is a potential problem and we recommend more studies be done in Lake Roosevelt to establish the extent of the problem.

The second explanation for the poor adult returns is that kokanee salmon may be entraining from Lake Roosevelt. Peven and Fielder (1989,1990) and Peven (1991) observed a significant number of kokanee salmon (348,128,721 fish respectively) at Rock Island Dam between April and August 1989.1990 and 1991, Peven and Fielder postulated that these fish were kokanee salmon from Lake Roosevelt or other lakes upstream. A portion of these fish were aged at 3,4 and 5 year olds. From 1992 to 1995, no large sockeye/kokanee salmon were mentioned in the Rock Island Dam Smolt Monitoring reports.

In the present study, biologists at both Rocky Reach and Rock Island Dams agreed to collect adipose clipped kokanee salmon during the smolt monitoring program (April 1 to August 3 1, 1996). The fish at these facilities averaged 282 mm and 8 of 12 were coded wire tagged 3 year olds. In addition, at Rocky Reach Dam, biologists reported seeing "several dozen" adipose clipped kokanee salmon smolts in April 1996 (J. Marco, Colville Confederated Tribal Biologist, personal communication). These fish had to be kokanee salmon smolts from Lake Roosevelt and not sockeye because no adipose clipped sockeye enter into the Columbia River above Rocky Reach Dam. Also, as many as 65 kokanee salmon (>200 mm) were observed at dams downstream of Rock Island Dam.

It is our perception that in years when there is low water retention time (WRT) and low reservoir elevation in Lake Roosevelt, entrainment is higher than in years when there is high WRT and high elevations. In 1991, Thatcher *et* al. (1993) estimated that 25,221 fish were lost from Lake Roosevelt based on 721 kokanee salmon seen during the smolt monitoring season. During that year the reservoir was drawn down to 1,235 ft with a water retention time of 18 days (Figure 2). During the next 4 years (from 1992 to 1995), the reservoir was not drawn down so severely which coincided with no large kokanee salmon being reported at Rock Island Dam. In 1996 however, the reservoir was drawn from February to March for flood control and reached 1227.2 ft in May with a water retention time of 12.7 days (Figure 2). Higher flows in 1991 and 1996 could have triggered kokanee salmon emigration and subsequently entrainment, while the lower flows from 1992 to 1995 together with the greater number of residualized smolts released, resulted in less entrainment from Lake Roosevelt. Also in 1996, there were a substantial number of tagged Lake Roosevelt rainbow trout recovered at downstream dams as far as Bonneville Dam (Cichosz *et al. this* report).

The Colville Confederated Tribes are currently monitoring entrainment from Lake Roosevelt by conducting hydroacoustic and vertical gill net surveys in the forebay of Grand Coulee Dam. This will provide a more direct method of monitoring entrainment from Lake Roosevelt. Results of their investigations, combined with continued assessment of kokanee salmon counted at Rocky Reach and Rock Island Dams wiIl provide better information to assess both entrainment and fish losses in future years.

Another hypothesis for low returns of adult kokanee salmon was addressed in Scholz et *al.* (1992). We have concern that Lake Whatcom fish may not provide the best genetic match for

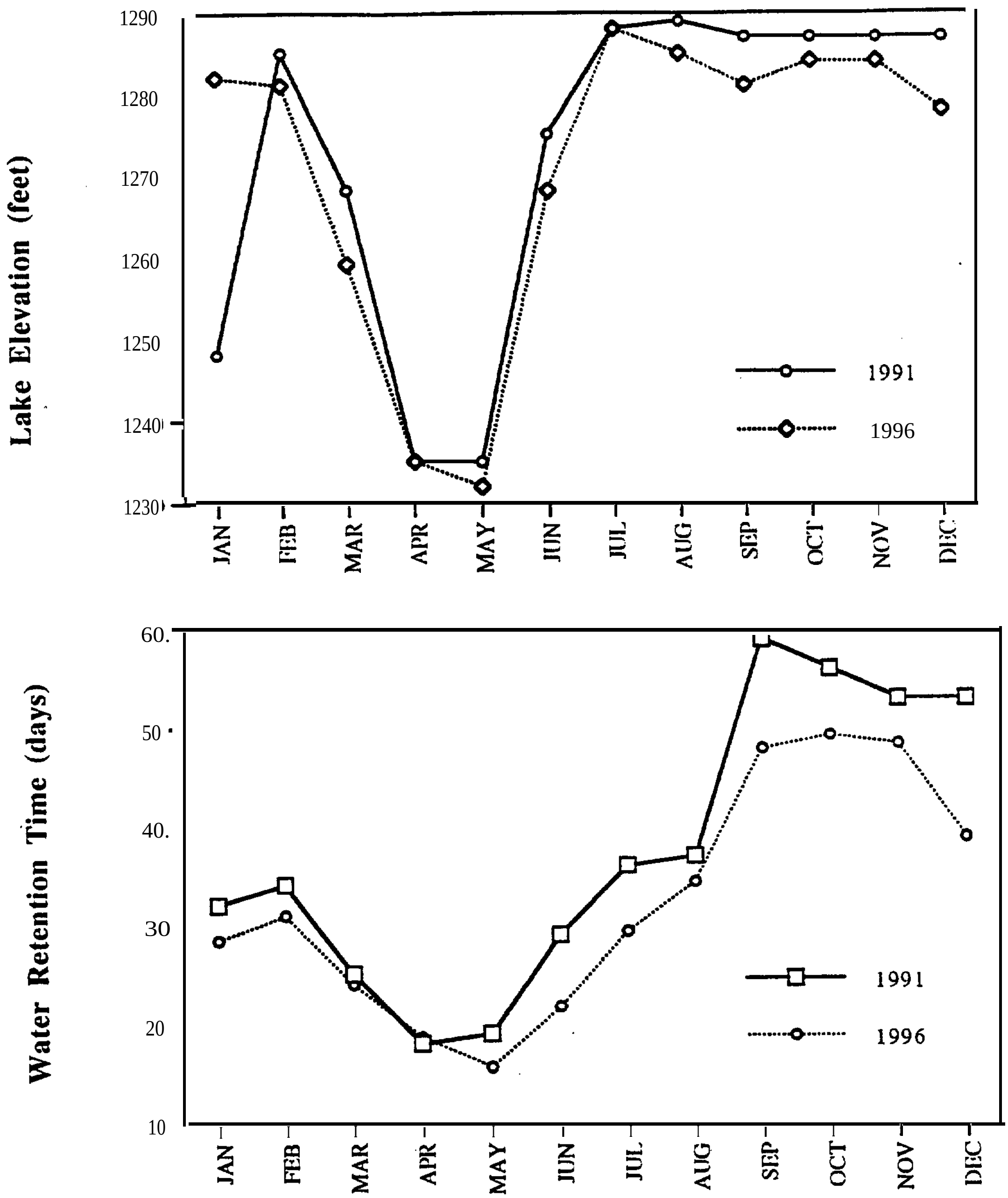


Figure 2. Lake elevation (feet) and water retention time (days) in Lake Roosevelt during 1991 and 1996.

Sherman Creek because in Lake Whatcom adult kokanee salmon migrate in an southerly direction to relocate their home tributary, whereas in Lake Roosevelt kokanee saImon migrate in a easterly, northerly and then westerly direction (See Appendix D, Notes on Genetic Control of Salmon Migration).

4.2 Kokanee Salmon Harvest

The second objective of the imprinting program was to assess the best times and locations to release kokanee salmon in order to improve angler harvest and returns to egg collection sites. Only nine kokanee salmon were observed in the creel and none of these had coded wire tags. Too few tagged kokanee salmon were obtained from anglers to assess harvest. Therefore, we recommend intensifying the creel to attempt to increase precision of harvest estimates.

4.3 Kokanee Salmon Spawning

In 1996, there were not enough 3 year old females recovered to spawn or to estimate fecundity. One of the problems associated with collecting eggs in 1995 was that when the females were electroshocked and moved to holding pens at Sherman Creek cove, the eggs ceased to develop and did not ripen. This could have been due to the fact that Sherman Creek water is approximately 10°F colder than Lake Roosevelt temperatures. One of the recommendations in 1995 was to induce spawning with pituitary horrnones or steroids. In 1996, there were only three 3 year olds and no 4 year old fish recovered. WDFW personnel offered a raceway at the Colville Hatchery to hold and spawn fish. Water temperatures at the Colville Hatchery were approximately 52°F (11°C). To determine if fish could be successfully spawned without inducing hormones, a few mature 2 and 3 year old fish (n=8) which were recovered at Sherman Creek were transported via live boxes to the Colville Hatchery (30 minutes transport time) where they were held for 2-4 weeks until they were spawned. These fish were successfully spawned without inducing hormones (M. Combs, Sherman Creek Hatchery Manager, personal communication). Thus, we may have a method of successfully spawning kokanee salmon in future years without the use of inducing hormones.

4.4 Management Recommendations

From information gathered in this report and from previous investigations of Tilson *et al.* (1994, 1995, 1996), it was concluded that imprinting and release site are important for maximizing adult recoveries at egg collection sites. Also, fish released as yearlings are recovered at greater rates than fish released as fry. Based upon the results of our investigations, we make the following recommendations for managing Lake Roosevelt kokanee salmon:

(1) To achieve the escapement goal of 1.45 million eggs, more fish must be released into the reservoir or return rates must be increased. For this to be accomplished hatchery managers must find ways to hold more yearling kokanee salmon.

(2) Monitor kokanee salmon entrainment.

(3) Provide adequate adult holding facilities at Sherman Creek so age 3 and age 4 fish are able to be kept for spawning purposes.

(4) Study feasibility of collecting additional spawning adults at Sheman Creek Hatchery.

(5) Continue the egg collection trap at Hawk Creek.

(6) Release equal numbers of chemically imprinted fish and non-imprinted fish from Sherman Creek Hatchery to determine if imprinted and non-imprinted fish reared and released at Sherman Creek home back in equal percentages.

(7) Locate alternative stocks of kokanee salmon.

(8) As part of the Lake Roosevelt Monitoring Program, further assess potential impacts of walleye predation at kokanee salmon release sites.

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APPENDIX A

Appendix A. Summary of kokanee salmon coded wire tagged at the Spokane Tribal Hatchery from 1994 to 1996. Tagging information includes stage at time of tagging, mean length (mm) and mean weight (g) at time of tagging, number tagged and number released after mortality,

CWT Code	Date Tagged	Stage @ Tagging	Mean Ln (mm)	Mean wt (g)	# Injected	# Tagged QCD	% Tagged	% Retention 1	# CWT Released	Year Released	Stage @ Release
62-52-21	Apr-94	smolt	156	36.7	11,253	11,101	98.6%	98.9	10,979	94	smolt
62-52-22	Apr-94	smolt	156	36.7	9,568	9,435	98.6%	99.0	9,341	94	smolt
62-52-23	Apr-94	smolt	156	36.7	11,128	10,904	98.0%	97.7	10,653	94	smolt
62-52-24	Apr-94	smolt	156	36.7	11,098	10,672	96.2%	97.5	10,405	94	smolt
62-52-25	Apr-94	smolt	157	37.8	'11,168	11,029	98.8%	98.7	10,886	94	smolt
62-52-26	Apr-94	smolt	157	37.8	11,236	11,117	98.9%	97.7	10,861	94	smolt
62-52-27	Apr-94	smolt	157	37.8	11,497	11,439	99.5%	98.4	11,256	94	smolt
62-52-28	Apr-94	smolt	167	45.1	11,709	11,512	98.3%	98.4	11,328	94	smolt
62-52-29	May-94	smolt	167	45.1	11,242	11,139	99.1%	98.0	10,919	94	smolt
62-52-30	May-94	smolt	167	45.1	10,899	10,836	99.4%	98.0	10,613	94	smolt
62-52-31	May-94	smolt	168	46.2	11,255	11,169	99.2%	98.3	10,291	94	smolt
62-52-32	May-94	smolt	168	46.2	14,786	13,677	92.5%	98.3	11,140	94	smolt
62-52-33	May-94	smolt	184	60.7	8,484	7,445	87.8%	98.9	7,303	94	smolt
111-2-8	Jun-94	fry	58	1.9	12,750	11,643	91.3%	84.0	9,780	94	fry
111-2-9	Jun-94	fry	58	1.9	11,018	10,132	92.0%	88.0	8,916	94	fry
62-52-34	Jun-94	fry	58	1.9‘	10,935	10,813	98.9%	91.3	10,099	94	fry
62-52-35	Jun-94	fry	54	1.5	11,252	11,078	98.5%	91.3	10,114	94	fry
62-52-36	Jun-94	fry	54	1.5	11,197	11,072	98.9%	91.6	10,147	94	fry
62-52-37	Jun-94	fry	57	1.8	11,206	11,050	98.6%	94.8	10,475	94	fry
62-52-38	Jun-94	fry	57	1.8	11,218	11,041	98.4%	94.8	10,467	94	fry

(1) Percent retention is estimated by randomly capturing 500 fish after 1 0-20 days and counting the number of fish with tags.

Appendix A. Continued

CWT Code	Date Tagged	Stage @ Tagging	Mean Ln (mm)	Mean wt (g)	# Injected	# Tagged QCD [1]	% Tagged	% Retention [2]	# CWT Released [3]	Year Released	Stage @ Release
62-54-37	Jun-95	fry	70	3.4	10,855	10,670	98.3	93.0	9,923	95	fry
62-54-38	Jun-95	fry	70	3.4	11,152	10,004	89.7	93.0	10,271	95	fry
62-54-39	Jun-95	fry	70	3.4	11,397	11,223	98.5	93.0	10,437	95	fry
62-54-40	Jun-95	fry	70	3.4	10,772	10,577	98.2	93.0	9,837	95	fry
62-54-48	Jul-95	fry	75	4.1	11,329	11,281	99.6	97.0	10,943	95	fry
62-52-39	Jun-94	fry	57	1.8	7,896	7,763	98.3	94.8	1,507	95	smolt
62-52-40	Jun-94	fry	60	2.1	10,982	10,919	99.4	95.2	5,682	95	smolt
62-52-41	Jun-94	fry	60	2.1	11,181	11,030	98.6	95.2	10,501	95	smolt
62-53-35	Jul-94	fry	61	2.2	11,189	11,052	98.8	95.2	5,704	95	smolt
62-53-36	Jul-94	fry	61	2.2	11,208	11,070	98.8	95.2	5,713	95	smolt
62-53-37	Jul-94	fry	61	2.2	11,218	11,144	99.3	95.2	5,789	95	smolt
62-53-38	Jul-94	fry	61	2.2	11,114	11,052	99.4	95.2	5,752	95	smolt
62-53-39	Jul-94	fry	57	1.8	11,187	11,154	99.7	95.2	5,806	95	smolt
62-53-40	Jul-94	fry	57	1.8	11,194	11,151	99.6	95.2	5,836	95	smolt
62-53-41	Jul-94	fry	52	1.4	11,180	11,102	99.3	94.3	10,293	95	smolt
62-53-42	Jul-94	fry	52	1.4	11,228	11,131	99.1	94.3	10,197	95	smolt
62-53-43	Jul-94	fry	52	1.4	11,243	11,172	99.4	94.3	10,244	95	smolt
62-53-44	Jul-94	fry	52	1.4	11,238	11,151	99.2	94.3	10,228	95	smolt
62-53-45	Jul-94	fry	52	1.4	11,354	11,210	98.7	94.3	10,301	95	smolt
62-53-46	Jul-94	fry	52	1.4	11,199	11,155	99.6	94.3	10,204	95	smolt
62-53-47	Jul-94	fry	55	1.6	11,239	11,173	99.4	95.7	10,224	95	smolt
62-53-48	Jul-94	fry	55	1.6	11,308	11,268	99.6	96.6	10,410	95	smolt
62-53-49	Jul-94	fry	55	1.6	11,286	11,215	99.4	96.6	10,363	95	smolt
62-53-51	Jul-94	fry	55	1.6	11,169	11,113	99.5	96.6	10,173	95	smolt
62-53-50	Jul-94	fry	55	1.6	11,190	11,128	99.4	96.6	10,285	95	smolt
62-51-25	Aug-94	fry	66	2.8	2,995	2,959	98.8	98.1	1,560	95	smolt
62-53-52	Aug-94	fry	66	2.8	11,203	11,147	99.5	96.6	10,457	95	smolt
62-53-53	Aug-94	fry	66	2.8	11,192	11,143	99.6	96.6	10,590	95	smolt
62-53-54	Aug-94	fry	66	2.8	11,177	11,129	99.6	96.6	10,576	95	smolt

Appendix A. Continued

CWT Code	Date Tagged	Stage @ Tagging	Mean Ln (mm)	Mean wt (g)	# Injected	# Tagged QCD 1	% Tagged	% Retention 2	# CWT Released 3	Year Released	Stage @ Release
62-53-55	Aug-94	fry	66	2.8	11,197	11,128	99.4	96.6	10,380	95	smolt
62-53-56	Aug-94	fry	78	4.6	11,192	11,081	99.0	96.6	10,542	95	smolt
62-53-57	Aug-94	fry	78	4.6	11,195	11,089	99.1	96.6	10,526	95	smolt
62-53-58	Aug-94	fry	66	2.8	11,183	11,136	99.6	97.9	1 0,725	95	smolt
62-53-59	Aug-94	fry	66	2.8	11,158	11,126	99.7	97.9	10,711	95	smolt
62-51-63	Nov-94	fingerling	116	15	11,658	11,574	99.3	95.4	10,939	95	smolt
62-51-26	Dec-94	fingerling	120	16.8	5,594	5,522	98.7	98.2	5,423	95	smolt
62-51-28	Dec-94	fingerling	120	16.8	8,375	8,301	99.1	98.9	8,210	95	smolt
62-51-34	Dec-94	fingerling	120	16.8	5,483	5,443	99.3	98.9	5,383	95	smolt
62-51-44	Dec-94	fingerling	116	15	6,007	5,960	99.2	95.4	5,637	95	smolt
62-51-24	Jan-95	fingerling	120	16.8	4,932	4,913	99.6	98.3	5,430	95	smolt
62-51-42	Jan-95	fingerling	120	16.8	4,712	4,669	99.1	97.5	4,552	95	smolt
62-51-48	Jan-95	fingerling	124	18.6	11,030	11	00.1	94.5	10,681	95	smolt
62-51-49	Jan-95	fingerling	124	18.6	8,081	8,056	99.7	98.0	7,895	95	smolt
62-51-50	Jan-95	fingerling	124	18.6	7,993	7,975	99.8	99.0	7,736	95	smolt
62-51-53	Feb-95	fingerling	124	18.6	452	448	99.1	99.1	444	95	smolt
62-51-54	Feb-95	fingerling	124	18.6	3,230	3,215	99.5	97.0	3,119	95	smolt

(1) Number actually tagged after running fish through quality control device.

(2) Percent retention is estimated by randomly capturing 500 fish 1 0-20 days after tagging and counting the number still tagged.

(3) Number cwt released is the number of fish released after mortality.

Appendix A. Continued

CWT Code	Date Tagged	Stage @ Tagging	Mean Ln (mm)	Mean wt (g)	# Injected	# Tagged QCD [1]	% Tagged	% Retention [2]	# CWT Released [3]	Year Released	Stage @ Release
62-54-31	Jun-95	fingerling	86	5.3	11,254	11,131	98.9	90.2	9,889	96	smolt
62-54-32	Jun-95	fingerling	86	5.3	11,776	11,445	97.2	95.2	10,733	96	smolt
62-54-33	Jun-95	fingerling	86	5.3	11,833	11,533	97.5	96.6	10,974	96	smolt
62-54-34	Jun-95	fingerling	86	5.3	10,134	10,007	98.7	94.4	9,305	96	smolt
62-54-35	Jun-95	fingerling	86	5.3	8,780	8,667	98.7	97.0	8,281	96	smolt
62-54-36	Jun-95	fingerling	86	5.3	5,260	5,014	95.3	96.8	4,781	96	smolt
62-54-37	Jun-95	fingerling	78	4.0	10,855	10,670	98.3	93.0	9,923	95	fingerling
62-54-38	Jun-95	fingerling	78	4.0	11,152	11,044	99.0	93.0	10,271	95	fingerling
62-54-39	Jun-95	fingerling	78	4.0	11,397	11,223	98.5	93.0	10,437	95	fingerling
62-54-40	Jun-95	fingerling	78	4.0	10,772	10,577	98.2	93.0	9,837	95	fingerling
62-54-41	Jun-95	fingerling	78	4.0	11,333	11,230	99.1	95.0	10,352	96	smolt
62-54-42	Jul-95	fingerling	78	4.0	11,340	11,152	98.3	95.0	10,435	96	smolt
62-54-43	Jul-95	fingerling	78	4.0	11,309	11,150	98.6	97.0	10,654	96	smolt
62-54-44	Jul-95	fingerling	78	4.0	11,342	11,257	99.3	97.0	10,869	96	smolt
62-54-45	Jul-95	fingerling	73	3.3	11,325	11,280	99.6	93.8	10,532	96	smolt
62-54-46	Jul-95	fingerling	73	3.3	11,357	11,278	99.3	94.2	10,576	96	smolt
62-54-47	Jul-95	fingerling	73	3.3	9,140	9,128	99.9	97.2	8,684	96	smolt
62-54-48	Jul-95	fingerling	73	3.3	11,329	11,281	99.6	97.0	10,943	96	smolt
62-54-49	Jul-95	fingerling	86	5.3	11,433	11,365	99.4	93.8	10,059	96	smolt
62-54-50	Jul-95	fingerling	86	5.3	11,351	11,254	99.1	97.4	10,343	96	smolt
62-54-51	Jul-95	fingerling	86	5.3	11,291	11,199	99.2	98.0	10,356	96	smolt
62-54-52	Jul-95	fingerling	86	5.3	11,319	11,254	99.4	97.5	10,433	96	smolt
62-54-53	Jul.95	fingerling	86	5.3	11,273	11,200	99.4	97.5	10,443	96	smolt
62-54-54	Jul-95	fingerling	86	5.3	11,255	11,195	99.5	96.2	10,298	96	smolt
62-54-55	Aug-95	fingerling	86	5.3	11,483	11,401	99.3	94.4	10,292	96	smolt
62-54-56	Aug-95	fingerling	86	5.3	11,514	11,429	99.3	91.8	9,899	96	smolt
62-54-57	Aug-95	fingerling	86	5.3	11,362	11,279	99.3	93.8	9,983	96	smolt
62-54-58	Aug-95	fingerling	86	5.3	11,205	11,099	99.1	96.6	10,117	96	smolt
62-54-59	Aug-95	fingerling	86	5.3	11,166	11,018	98.7	96.2	10,001	96	smolt

Appendix A. Continued

CWT Code	Date Tagged	Stage @ Tagging	Mean Ln (mm)	Mean Wt (g)	# injected	# Tagged QCD 1	% Tagged	% Retention 2	# CWT Released 3	Year Released	Stage @ Release
62-54-60	Aug-95	fingerling	86	5.3	11,062	10,949	99.0	95.2	9,835	96	smolt
62-54-61	Aug-95	fingerling	86	5.3	11,182	11,054	98.9	94.6	9,867	96	smolt
62-54-62	Aug-95	fingerling	98	7.8	11,143	11,083	99.5	97.5	10,675	96	smolt
62-54-63	Aug-95	fingerling	98	7.8	11,096	10,999	99.1	97.2	10,561	96	smolt
62-55-03	Aug-95	fingerling	98	7.8	6,388	6,373	99.8	97.5	4,533	96	smolt
62-55-03	Aug-95	fingerling	98	7.8	4,969	4,929	99.2	97.5	6,102	96	smolt
62-55-05	Aug-95	fingerling	98	7.8	11,392	11,308	99.3	98.0	10,457	96	smolt
62-55-06	Sep-95	fingerling	98	7.8	11,363	11,324	99.7	96.2	10,279	96	smolt
62-55-07	Sep-95	fingerling	98	7.8	11,497	11,459	99.7	93.2	10,077	96	smolt
62-55-09	Sep-95	fingerling	98	7.8	5,822	5,810	99.8	97.2	7,575	96	smolt
62-55-29	Mar-96	smolt	144	24.9	32,556	32,386	99.5	86.0	28,184	96	smolt
62-55-30	Apr-96	smolt	166	38.0				75.0	14,290	96	smolt
62-55-31	Mar-96	smolt	157	32.0	40,137	39,956	99.5	81.0	36,177	96	smolt

(1) Number actually tagged after running fish through quality control device.

(2) Percent retention is estimated by randomly capturing 500 fish 10-20 days after tagging and counting the number still tagged.

(3) Number cwt released is the number of fish released after mortality.

APPENDIX B

Appendix B. Total number of kokanee salmon released into Lake Roosevelt from 1992 to 1996. Numbers taken from Appendix C.

STAGE @ RELEASE	1992			1993			1994			1995		
	CWT (n)	AD ONLY (n)	TOTAL (n)	CWT (n)	AD ONLY (n)	TOTAL (n)	CWT (n)	AD ONLY (n)	TOTAL (n)	CWT (n)	AD ONLY (n)	TOTAL (n)
FRY	171,452	21,983	193,435	241,952	3,105	245,057	59,899	8,174	68,073	51,411	4,094	55,505
SMOLT	132,029	0	132,029	80,468	1,845	82,313	137,457	5,225	142,682	369,106	16,944	386,050

STAGE @ RELEASE	1996		
	CWT (n)	AD ONLY (n)	TOTAL (n)
FRY	0	0	0
SMOLT	406,901	26,008	432,909

APPENDIX C

Appendix C. Summary of marked kokanee salmon released into Lake Roosevelt from 1992 to 1996.

Cohort	Exposure Odor	Exposure Stage	CWT Code	Number Tagged (n)	Adipose clipped only (n)	Release Location	Stage @ Release	Year Released	Comments
90	MOR	Smolt	62-51-l 2	7,501		Sherman Cr	Smolt	92	
90	MOR	Smolt	62-51-13	2,525		Sherman Cr	Smolt	92	
90	MOR	Smolt	62-51-14	5,392		Sherman Cr	Smolt	92	
90	MQR	Smolt	62-51-15	1,796		Sherman Cr	Smolt	92	
90	MOR	Smolt	62-51-l 6	3,734		Sherman Cr	Smolt	92	
90	MOR	Smolt	62-51-17	5,691		Sherman Cr	Smolt	92	
90	MOR	Smolt	62-51-18	4,491		Sherman Cr	Smolt	92	
90	MOR	Smolt	62-51-19	3,492		Sherman Cr	Smolt	92	
90	PEA	Smolt	62-51-13	4,855		Sherman Cr	Smolt	92	
90	PEA	Smolt	62-51-14	1,665		Sherman Cr	Smolt	92	
90	PEA	Smolt	62-51-15	7,717		Sherman Cr	Smolt	92	
90	PEA	Smolt	62-51-16	6,769		Sherman Cr	Smolt	92	
90	PEA	Smolt	62-51-l 7	5,477		Sherman Cr	Smolt	92	
90	PEA	Smolt	62-51-18	7,535		Sherman Cr	Smolt	92	
90	PEA	Smolt	62-51-19	9,215		Sherman Cr	Smolt	92	
90	PEA	Smolt	62-51-21	5,143		Sherman Cr	Smolt	92	
90	PEA	Smolt	62-51-22	3,211		Sherman Cr	Smolt	92	
90	NONE	-	62-51-12	9,756		Blue Cr	Smolt	92	Lk Roos. Brood
90	NONE	-	62-51-20	7,362		Sherman Cr	Smolt	92	Lk Roos. Brood
90	NONE	-	62-51-20	3,153		Lil Falls	Smolt	92	Lk Roos. Brood
90	NONE	-	62-51-21	6,299		Sherman Cr	Smolt	92	Lk Roos. Brood
90	NONE	-	62-51-22	4,124		Sherman Cr	Smolt	92	Lk Roos. Brood
90	NONE	-	62-51-22	4,075		Lil Falls	Smolt	92	Lk Roos. Brood
90	NONE		62-51-23	1,872		Sherman Cr	Smolt	92	Lk Roos. Brood
90	NONE	-	62-51-23	9,159		Lil Falls	Smolt	92	Lk Roos. Brood
			TOTAL	132,029	0				

Appendix C. Continued

Cohort	Exposure Odor	Exposure Stage	CWT Code	Number Tagged (n)	Adipose clipped only (n)	Release Location	Stage @ Release	year Released	Comments
91	MOR	eye-hatch	62-51-28	2,967	225	Sherman Cr	fry	92	
91	MOR	eye-hatch	62-51-44	3,507	668	Sherman Cr	fry	92	
91	PEA	eye-hatch	62-51-27	10,595	798	Sherman Cr	fry	92	Ad,RV 2,000
91	MOR	hatch	62-51-30	10,169	1,006	Sherman Cr	fry	92	Ad,RV 2,000
91	MOR	hatch	62-51-32	10,053	994	Sherman Cr	fry	92	Ad,RV 2,000
91	PEA	hatch	62-51-29	10,665	803	Sherman Cr	fry	92	Ad,RV 2,000
91	PEA	hatch	62-51-31	10,599	1,048	Sherman Cr	fry	92	Ad,RV 2,000
91	MOR	h-su	62-51-37	10,411	1,030	Sherman Cr	fry	92	Ad,RV 2,000
91	PEA	h-su	62-51-33	9,455	1,413	Sherman Cr	fry	92	Ad,RV 2,000
91	MOR	swimup	62-51-36	7,617	753	Sherman Cr	fry	92	Ad,RV 2,000
91	PEA	swimup	62-51-35	9,323	1,393	Sherman Cr	fry	92	Ad,RV 2,000
91	MOR	Feb-fry	62-51-24	4,627	881	Sherman Cr	fry	92	Ad,RV 2,000
91	MOR	Feb-fry	62-51-25	6,247	1,190	Sherman Cr	fry	92	Ad,RV 2,000
91	MOR	Feb-fry	62-51-26	6,089	1,160	Sherman Cr	fry	92	Ad,RV 2,000
91	PEA	Feb-fry	62-51-34	5,242	783	Sherman Cr	fry	92	Ad,RV 2,000
91	MOR	Mar-fry	62-51-38	8,916	882	Sherman Cr	fry	92	Ad,RV 2,000
91	PEA	Mar-fry	62-51-39	9,520	1,298	Sherman Cr	fry	92	Ad,RV 2,000
91	MOR	Apr-fry	62-51-40	10,072	1,373	Sherman Cr	fry	92	Ad,RV 2,000
91	PEA	Apr-fry	62-51-41	10,142	1,383	Sherman Cr	fry	92	Ad,RV 2,000
91	MOR	May-fry	62-51-42	5,744	1,094	Sherman Cr	fry	92	
91	PEA	May-fry	62-51-43	9,492	1,808	Sherman Cr	fry	92	
			TOTAL	171,452	21,983				

Appendix C. Continued

Cohort	Exposure Odor	Exposure Stage	CWT Code	Number Tagged (n)	Adipose clipped only (n)	Release Location	Stage @ Release	Year Released	Comments
91	PEA	Smolt	62-51-54	8,196	184	Blue Cr	smolt	93	
91	PEA	Smolt	62-51-48	732	19	Sherman Cr	smolt	93	
91	PEA	Smolt	62-51-49	3,454	89	Sherman Cr	smolt	93	
91	PEA	Smolt	62-51-50	3,567	91	Sherman Cr	smolt	93	
91	MOR	Smolt	62-H-45	12,396	318	Sherman Cr	smolt	93	
91	MOR	Smolt	62-51-46	12,664	325	Sherman Cr	smolt	93	
91	MOR	Smolt	62-51-47	12,970	333	Sherman Cr	smolt	93	
91	NONE	-	62-51-51	9,751	179	Sherman Cr	smolt	93	
91	NONE	-	62-51-52	9,800	180	Sherman Cr	smolt	93	
91	NONE	, -	62-51-53	6,938	127	Sherman Cr	smolt	93	
			TOTAL	80,488	1,845	82,313			

Appendix C. Continued

Cohort	Exposure Odor	Exposure Stage	CWT Code	Number Tagged (n)	Adipose clipped only (n)	Release Location	Stage @ Release	Year Released	Comments
92	PEA	hatch	62-52-32	325		Chamokane Cr	2 year old	94	
92	PEA	eye-hatch	62-52-31	325		Chamokane Cr	2 year old	94	
92	MOR	su-rel	62-52-07	10,870	121	Sherman Cr	fry	93	
92	MOR	su-rel	62-51-55	10,802	266	Sherman Cr	fry	93	
92	PEA	su-rel	62-52-06	10,896	121	Sherman Cr	fry	93	
92	MOR	eye-hatch	62-51-56	10,961	269	Sherman Cr	fry	93	
92	MOR	eye-hatch	62-52-09	3,394	38	Sherman Cr	fry	93	
92	MOR	eye-hatch	62-52-09	7,509	53	Sherman Cr	fry	93	
92	PEA	eye-hatch	62-51-57	10,721	264	Sherman Cr	fry	93	
92	PEA	eye-hatch	62-52-l 0	10,960	77	Sherman Cr	fry	93	
92	PEA	eye-hatch	62-52-l 6	10,863	121	Sherman Cr	fry	93	
92	MOR	hatch	62-52-l 3	11,001	78	Sherman Cr	fry	93	
92	MOR	hatch	62-52-i 7	10,863	121	Sherman Cr	fry	93	
92	MOR	hatch	62-52-I 4	10,916	77	Sherman Cr	fry	93	
92	MOR	hatch	62-52-I 5	9,499	67	Sherman Cr	fry	93	
92	MOR	hatch	62-51-59	10,086	221	Sherman Cr	fry	93	
92	PEA	hatch	62-51-58	10,767	265	Sherman Cr	fry	93	
92	PEA	hatch	62-52-l 1	10,971	78	Sherman Cr	fry	93	
92	PEA	hatch	62-52-l 2	11,022	78	Sherman Cr	fry	93	
92	MOR	h-su	62-51-60	10,938	122	Sherman Cr	fry	93	
92	PEA	h-su	62-51-61	11,791	144	Sherman Cr	fry	93	
92	MOR	swimup	62-52-03	10,908	121	Sherman Cr	fry	93	
92	PEA	swimup	62-52-05	10,885	121	Sherman Cr	fry	93	
92	MOR	swimup	62-52-l 8	2,712	31	Barnaby Cr	fry	93	
92	MOR	h-su	62-52-l 8	2,712	30	Barnaby Cr	fry	93	
92	PEA	eye-hatch	62-52-l 8	2,712	30	Barnaby Cr	fry	93	
92	MOR	eye-hatch	62-52-l 8	2,712	30	Barnaby Cr	fry	93	
92	PEA	swimup	62-52-l 9	3,637	41	Barnaby Cr	fry	93	
92	MOR	hatch	62-52-l 9	3,637	40	Barnaby Cr	fry	93	
92	MOR	h-su	62-52-l 9	3,637	40	Barnaby Cr	fry	93	

Table D.13 Section 2 catch per unit effort (fish/hour - harvest and release) in Lake Roosevelt from December, 1995 through November, 1996.

Species	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	Annual Mean
kokanee	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.000**
rainbow trout	0.000	0.000	0.175	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.043	0.000	**0.011**
walleye	0.000	0.000	0.000	0.000	0.000	0.000	0.034	0.407	0.000	0.000	0.000	0.000	**0.045**
smallmouth bass	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.027	0.000	0.000	0.000	0.000	**0.003**
sturgeon	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.000**
other species*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.000**
Monthly Mean	**0.000**	**0.000**	**0.175**	**0.009**	**0.000**	**0.000**	**0.034**	**0.434**	**0.000**	**0.000**	**0.043**	**0.000**	**0.059**

*Includes yellow perch, largemouth bass, suckers, squawfish, black crappie, chinook, bullhead, etc...

Appendix C. Continued

Cohort	Exposure Odor	Exposure Stage	CWT Code	Number Tagged (n)	Adipose clipped only (n)	Release Location	Stage @ Release	Year Released	Comments
92	MOR	eye-hatch	62-52-31	10,291	975	Blue Cr	smolt	94	
92	MOR	eye-hatch	62-52-32	3,334	91	Blue Cr	smolt	94	
92	MOR	hatch	62-52-30	10,613	338	Sherman Cr	smolt	94	
92	MOR	hatch	62-52-22	2,822	46	Sherman Cr	smolt	94	
92	PEA	hatch	62-52-32	7,806	130	A-Frame	smolt	94	
92	PEA	eye-hatch	62-52-33	8,352	132	A-Frame	smolt	94	
92	MOR	h-su	62-52-26	4,604	232	Sherman Cr	smolt	94	
92	MOR	h-su	62-52-29	10,919	546	Sherman Cr	smolt	94	
92	MOR	swimup	62-52-2 1	10,979	274	Sherman Cr	smolt	94	
92	MOR	swimup	62-52-22	6,938	190	Sherman Cr	smolt	94	
92	PEA	swimup	62-52-23	10,653	475	Sherman Cr	smolt	94	
92	PEA	swimup	62-52-24	10,405	694	Sherman Cr	smolt	94	
92	PEA	su-fry	62-52-25	10,886	282	Sherman Cr	smolt	94	
92	PEA	su-fry	62-52-26	6,271	198	Sherman Cr	smolt	94	
92	NONE		62-52-27	11,256	241	KF Net Pen	smolt	94	Lk Roos. Brood
92	NONE		62-52-28	11,328	381	KF Net Pen	smolt	94	Lk Roos. Brood
			TOTAL	137,457	5,225	142,682			
93	MOR	al-su	111-2-8	9,780	2,970	Sherman Cr	fry	94	
93	MOR	al-su	111-2-9	8,916	1,216	Sherman Cr	fry	94	
93	MOR	h-su	62-52-35	10,1 14	1,312	Sherman Cr	fry	94	
93	MOR	h-su	62-52-36	10,147	1,151	Sherman Cr	fry	94	
93	PEA	al-su	62-52-37	10,475	774	Sherman Cr	fry	94	
93	PEA	al-su	62-52-38	10,467	751	Sherman Cr	fry	94	
			TOTAL	59,899	8,174	68,073			

Appendix C. Continued

Cohort	Exposure Odor	Exposure Stage	CWT Code	Number Tagged (n)	Adipose clipped only (n)	Release Location	Stage @ Release	Year Released	Comments
93	PEA	al-su/smolt	62-51-25	1,560	20	Sherman Cr	smolt	95	
93	PEA	h-su/smolt	62-53-41	10,293	704	Sherman Cr	smolt	95	
93	PEA	h-su/smolt	62-53-42	10,197	697	Sherman Cr	smolt	95	
93	PEA	h-uw/smolt	62-53-43	10,244	677	Sherman Cr	smolt	95	
93	PEA	h-su/smolt	62-53-44	10,228	688	Sherman Cr	smolt	95	
93	PEA	h-su/smolt	62-53-45	10,301	728	Sherman Cr	smolt	95	
93	PEA	h-su/smolt	62-53-46	10,204	674	Sherman Cr	smolt	95	
93	PEA	h-su/smolt	62-53-52	10,457	424	Sherman Cr	smolt	95	
93	PEA	h-su/smolt	62-53-53	10,590	418	Sherman Cr	smolt	95	
93	PEA	h-su/smolt	62-53-54	10,576	418	Sherman Cr	smolt	95	
93	PEA	h-su/smolt	62-53-55	10,380	432	Sherman Cr	smolt	95	
93	PEA	h-su/smolt	62-53-58	10,725	275	Sherman Cr	smolt	95	
93	PEA	h-su/smolt	62-53-59	10,711	263	Sherman Cr	smolt	95	
93	NONE	-	62-51-28	8,210	165	Spokane R	smolt	95	Lk Roos. Brood
93	NONE	-	62-51-34	5,383	100	Spokane R	smolt	95	Lk Roos. Brood
93	NONE	-	62-51-42	4,552	160	Spokane R	smolt	95	Lk Roos. Brood
93	NONE	-	62-51-49	8,210	165	Spokane R	smolt	95	Lk Roos. Brood
93	NONE	-	62-51-50	7,736	257	Spokane R	smolt	95	Lk Roos. Brood
93	NONE	·	62-51-53	444	8	Spokane R	smolt	95	Lk Roos. Brood
93	NONE	-	62-51-54	3,119	111	Spokane R	smolt	95	Lk Roos. Brood
93	NONE	-	62-51-24	5,430	102	Barnaby Cr	smolt	95	Lk Roos. Brood
93	NONE	-	62-51-26	5,423	174	Barnaby Cr	smolt	95	Lk Roos. Brood
93	NONE	-	62-51-48	10,681	349	Barnaby Cr	smolt	95	Lk Roos. Brood
93	NONE		62-52-40	10,295	573	KF Net Pen	smolt	95	Lk Roos. Brood
93	MOR	h-su	62-52-41	10,501	680	KF Net Pen	smolt	95	
93	MOR	h-su	62-53-35	10,522	667	KF Net Pen	smolt	95	
93	MOR	h-su	62-53-36	10,539	669	KF Net Pen	smolt	95	
93	PEA	h-su	62-53-37	10,609	609	KF Net Pen	smolt	95	
93	PEA	h-su	62-53-38	10,522	574	KF Net Pen	smolt	95	
93	PEA	h-su	62-53-39	10,619	568	KF Net Pen	smolt	95	
93	PEA	h-su	62-53-40	10,616	579	KF Net Pen	smolt	95	

Appendix C. Continued

Cohort	Exposure Odor	Exposure Stage	CWT Code	Number Tagged (n)	Adipose clipped only (n)	Release Location	Stage @ Release	Year Released	Comments
93	MOR	al-su	62-53-56	10,542	439	KF Net Pen	smolt	95	
93	MOR	al-su	62-53-57	10,526	473	KF Net Pen	smolt	95	
93	NONE	-	62-52-39	10,130	736	KF Net Pen	smolt	95	Lk Roos. Brood
93	MOR	h-su/smolt	62-51-44	5,637	68	Sherman Cr	smolt	95	
93	MOR	h-su/smolt	62-51-63	10,939	212	Sherman Cr	smolt	95	
93	MOR	al-su/smolt	62-53-47	10,224	426	Sherman Cr	smolt	95	
93	MOR	al-su/smolt	62-53-48	10,410	400	Sherman Cr	smolt	95	
93	MOR	al-su/smolt	62-53-49	10,363	432	Sherman Cr	smolt	95	
93	MOR	al-su/smolt	62-53-50	10,285	417	Sherman Cr	smolt	95	
93	MOR	al-su/smolt	62-53-51	10,173	413	Sherman Cr	smolt	95	
			TOTAL	369,106	16,944	386,050			
94	MOR	h-su	62-54-37	9,923	932	Sherman Cr	fry	95	
94	MOR	h-su	62-54-38	10,271	881	Sherman Cr	fry	95	
94	MOR	h-su	62-54-39	10,437	960	Sherman Cr	fry	95	
94	MOR	h-su	62-54-40	9,837	935	Sherman Cr	fry	95	
94	MOR	h-su	62-54-48	10,943	386	Chamokane Cr	fry	95	
			TOTAL	51,411	4,094	55,505			

Appendix C. Continued

Cohort	Exposure Odor	Exposure Stage	CWT Code	Number Tagged (n)	Adipose clipped only (n)	Release Location	Stage @ Release	Year Released	Comments
94	NONE	–	62-54-31	9,889	1,196	2 River NP	smolt	May-96	Lk Roos. Brood
94	NONE	–	62-54-32	10,733	867	2 River NP	smolt	May-96	Lk Roos. Brood
94	NONE		62-54-33	10,974	682	2 River NP	smolt	May-96	Lk Roos. Brood
94	NONE		62-54-34	9,305	677	2 River NP	smolt	May-96	Lk Roos. Brood
94	NONE	--	62-54-35	8,281	367	2 River NP	smolt	May-96	Lk Roos. Brood
94	NONE	–	62-54-36	4,781	400	2 River NP	smolt	May-96	Lk Roos. Brood
94	MOR	h-su	62-54-41	10,352	656	2 Riv/HC NP	smolt	May-96	
94	MOR	h-su	62-54-42	10,435	735	2 Riv/HC NP	smolt	May-96	
94	MOR	h-su	62-54-43	10,654	487	2 Riv/HC NP	smolt	May-96	
94	MOR	h-su	62-54-44	10,869	421	KF Net Pen	smolt	Apr-96	
94	MOR	h-su	62-54-45	10,532	741	KF Net Pen	smolt	Apr-96	
94	MOR	h-su	62-54-46	10,576	729	KF Net Pen	smolt	Apr-96	
94	MOR	h-su	62-54-47	8,684	262	KF Net Pen	smolt	Apr-96	
94	MOR	h-su/smolt	62-54-49	10,059	729	Sherman Cr	smolt	Jul-96	
94	MOR	h-su/smolt	62-54-50	10,343	368	Sherman Cr	smolt	Jul-96	
94	MOR	h-su/smolt	62-54-51	10,356	298	Sherman Cr	smolt	Jul-96	
94	PEA	h-su/smolt	62-54-52	10,433	390	Sherman Cr	smolt	Jul-96	
94	PEA	h-su/smolt	62-54-53	10,443	337	Sherman Cr	smolt	Jul-96	
94	PEA	h-su/smolt	62-54-54	10,298	464	Sherman Cr	smolt	Jul-96	
94	PEA	h-su/smolt	62-54-55	10,292	688	Sherman Cr	smolt	Jul-96	
94	MOR	h-su/smolt	62-54-56	9,899	965	Sherman Cr	smolt	Jul-96	
94	MOR	h-su/smolt	62-54-57	9,983	738	Sherman Cr	smolt	Jul-96	
94	MOR	h-su/smolt	62-54-58	10,117	455	Sherman Cr	smolt	Jul-96	
94	MOR	h-su/smolt	62-54-59	10,001	535	Sherman Cr	smolt	Jul-96	
94	MOR	h-su/smolt	62-54-60	9,835	603	Sherman Cr	smolt	Jul-96	
94	MOR	h-su/smolt	62-54-61	9,867	710	Sherman Cr	smolt	Jul-96	
94	MOR	h-su	62-54-62	10,675	332	KF Net Pen	smolt	Apr-96	
94	MOR	h-su	62-54-63	10,561	400	KF Net Pen	smolt	Apr-96	
94	MOR	h-su/smolt	62-55-03	4,533	154	Sherman Cr	smolt	Jul-96	
94	MOR	h-su	62-55-03	6,102	171	KF Net Pen	smolt	Apr-96	
94	MOR	h-su/smolt	62-55-05	10,457	292	Sherman Cr	smolt	Jul-96	

Appendix C. Continued

Cohort	Exposure Odor	Exposure Stage	CWT Code	Number Tagged (n)	Adipose clipped only (n)	Release Location	Stage @ Release	Year Released	Comments
94	MOR	h-su/smolt	62-55-06	10,279	443	Sherman Cr	smolt	Jul-96	
94	MOR	h-su/smolt	62-55-07	10,077	771	Sherman Cr	smolt	Jul-96	
94	MOR	h-su/smolt	62-55-09	7,575	241	Sherman Cr	smolt	Jul-96	
94	PEA	h-su/smolt	62-55-29	28,184	2,986	Sherman Cr	smolt	Jul-96	
94	PEA	h-su/smolt	62-55-30	14,290	758	Barnaby Cr	smolt	Jun-96	
94	PEA	h-su/smolt	62-55-31	36,177	3,960	Spokane R	smolt	Jun-96	
			TOTAL	406,901	26,008	432,909			

APPENDIX D

Notes on the Genetic Control of Salmon Migration

Previous investigations suggest that there may be genetic control to the direction cues salmon use to locate their nursery lake and to home back to their natal stream. In regard to the imprinting and homing of salmonids, Bams (1976) has argued that there is a genetic component. He transplanted pink salmon (0. ***gorbuscha)*** eggs from their original tributary (Stream A) to a second one (Stream B). One group of donor stream eggs was cross-fertilized by males from the recipient stream (A eggs X B sperm); while the other group were pure bred donor stream fish (A eggs X A sperm) transplanted into the recipient stream. Both groups were raised in the recipient stream and then marked before they migrated to the sea. About equal numbers of both groups left the recipient stream, but only about half as many from the pure donor stream stock (A X A) as from the hybrid stock (A X **B)** returned to it. Bams concluded that, *"imprinting alone brought back some of the pure donor stock, and "addition of the local mule* genetic *complement improved the return to the river of release."*

Brannon (1967,1972) investigated genetic control of migratory behavior in newly emerged sockeye salmon fry into nursery lakes. Fertilized eggs from three stocks -- outlet streams, inlet streams and lake shoreline areas -- were transferred to a fish hatchery remote from their lakes of origin and incubated under controlled conditions very different from their natural environments. The alevins and fry were then tested in a laboratory apparatus to determine their preferred direction of migration and each stock responded to water current with the same behavior pattern exhibited in its natural environment. Chilko River stock sockeye, which migrate upstream from the outlet stream into the nursery lake, exhibited a strong preference (82.3%) to swim upstream (positive rheotaxis). Francois Lake stock sockeye fry, which must migrate downstream from an inlet stream to the nursery lake, exhibited a strong preference (80%) to swim downstream (negative rheotaxis). Cultus Lake stock sockeye, which exhibit shoreline spawning in the lake and require, therefore, no migration to reach the nursery lake, showed random rheotactic behavior. This study suggests that there is genetic control of migratory behavior of fry.

There is also evidence for magnetic field detection in salmonids. Quinn (1980) and Quinn et *al.* (198 1) found that migrating sockeye salmon fry used both celestial and magnetic compass orientation to locate their nursery lake. Quinn reasoned that if juvenile salmon posses the ability to use magnetic cues in association with a genetic program of directional preference, then it is likely that salmon adults also have a similar capability: Quinn speculated that the highly patterned adult migrations in the ocean are cued at least in part by magnetic field perception. Adult salmon feeding in the North Pacific Ocean, migrate south of the Aleutian chain in a counter-clockwise gyre. At specific times of the year and at particular geographic locations, specific stocks break out of this pattern and swim to the mouth of the home river (Neave 1964), suggesting that patterned migration routes are used by adults reminiscent of the patterns reported for smolts during their emigration from large, complex lakes (Groot 1965).

We believe that other stocks should be located to provide source fish that might be better matched for Lake Roosevelt. Potential donor stocks should have the following characteristics and migratory tendencies:

(1) Donor stock fry should have an innate preference to migrate upstream to a nursery lake. Such a tendency may cause the fish to orient upstream in Lake Roosevelt, which would aid in keeping them away from Grand Coulee Dam; and/or

(2) The donor stock should spawn in tributaries where they must orient at 90” (East), 180° (South) and then 270° (West) to reach the nursery lake as fry and 90” (East), to 360° (North) and 270° (West) to relocate their natal tributary as adults. This is because smolts leaving the Sherman Creek site must initially travel in a 90°-180°-270° direction to reach the principle feeding areas in Lake Roosevelt (the confluence of the Spokane River to the forebay of Grand Coulee Dam). Adults returning to Sherman Creek from the forebay will have to travel at azimuths of 90°-360°-270° to relocate Sherman Creek.

One potential donor stock would be a native stock of kokanee salmon that spawn in Big Sheep Creek, a tributary that flows into the Columbia River just south of the international border. Apparently, these fish have successfully resided in Lake Roosevelt since the reservoir was closed (58 years ago). However, we have observed only four kokanee salmon in Big Sheep Creek in 1995 and 1996. An alternative approach would be to intentionally find a poorly matched donor stock from outside the Columbia Basin in an attempt to force fish to ignore innate directional preferences and rely solely on imprinted cues for relocating the home tributary. Scholz et *al.* (1975, 1978) found that introduction of West Coast (Columbia River) salmonids into Great Lakes tributaries has resulted in excellent returns to the transplant site, whereas transplanting salmonid species into different tributaries on the West Coast has met with more limited success (reviewed by Ricker 1972). Therefore, stocks from a different latitude, e.g., Fraser or Skeena River, British Columbia or Alaskan stocks might be appropriate. The reason this may work is that salmon seem to posses two distinctive orientation mechanisms. The first is an innate genetic program of directional preference cued by celestial (sun compass, polarized light) navigation, geomagnetic fields and perhaps, conspecific pheromones. This mechanism may function primarily in juvenile migrations and the open water phase of the adult migration. The second is an imprinted olfactory memory of the homestream water. This mechanism may function primarily in the upstream migration of adults to natal spawning tributaries. Therefore, if fish are transplanted a long distance, since their genetic program is not closely matched to the new environment, the fish must ignore their innate mechanism (which may be nonfunctional if cued by geomagnetic fields) and rely solely on imprinting to relocate the transplant site.